NMC

Horizon Report > 2014 Library Edition

The *NMC Horizon Report > 2014 Library Edition* examines key trends, significant challenges, and emerging technologies for their impact on academic and research libraries across the globe.

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The *NMC Horizon Report: 2014 Library Edition*
is a collaboration between the NEW MEDIA CONSORTIUM, UNIVERSITY OF APPLIED SCIENCES (HTW) CHUR, TECHNISCHE INFORMATIONSBIBLIOTHEK (TIB) HANNOVER, and ETH-BIBLIOTHEK ZURICH.

The research behind the *NMC Horizon Report: 2014 Library Edition* is a collaboration between the New Media Consortium (NMC), University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB) Hannover, and ETH-Bibliothek Zurich. Their critical participation in the production of this report and their strong support for the NMC Horizon Project is gratefully acknowledged.

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Introduction

The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a 12-year effort established in 2002 that annually identifies and describes emerging technologies likely to have a large impact over the coming five years in every sector of education around the globe. This volume, the *NMC Horizon Report: 2014 Library Edition*, examines key trends, significant challenges, and emerging technologies for their potential impact on academic and research libraries worldwide. While there are many local factors affecting libraries, there are also issues that transcend regional boundaries and common questions; it was with these questions in mind that this report was created. The *NMC Horizon Report: 2014 Library Edition* was produced by the NMC in collaboration with University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB) Hannover, and ETH-Bibliothek Zurich.

Each of the four global editions of the *NMC Horizon Report* — higher education, K-12 education, academic and research libraries, and museums — highlights six emerging technologies or practices that are likely to enter mainstream use within their focus sectors over the next five years. Major trends and challenges that will affect current practice over the same period frame these discussions. For the *NMC Horizon Report: 2014 Library Edition*, an expert panel identified 18 topics very likely to impact technology planning and decision-making: six key trends, six significant challenges, and six important developments in technology. The discussions of trends and technologies have been organized into three time-related categories; challenges are discussed within a similar three-part framework related to the scope of the challenge.

To create the report, an international body of experts from library management, education, technology, and other fields was convened as a panel. Over the course of three months in the spring of 2014, the 2014 Horizon Project Library Expert Panel came to a consensus about the topics that would appear here in the *NMC Horizon Report: 2014 Library Edition*.

Each topic closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report. These resources, along with a wide collection of other helpful projects and readings, can all be found in the project's open content database that is accessible via the free NMC Horizon EdTech Weekly App for iOS[1] and Android devices.[2] All the background materials for the *NMC Horizon Report: 2014 Library Edition*, including the research data, the preliminary selections, the topic preview, and this publication, can be downloaded for free on iTunes U.[3]

An expert panel identified 18 topics very likely to impact technology planning and decision-making: six key trends, six significant challenges, and six important developments in technology.

The process used to research and create the *NMC Horizon Report: 2014 Library Edition* is rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are informed by both primary and secondary research. Dozens of meaningful trends, challenges, and emerging technologies are examined for possible inclusion in the report for each edition.

Every report draws on the considerable expertise of an international expert panel that first considers a broad set of important trends, challenges, and emerging technologies, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and technologies is selected. This process takes place online, where it is captured in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window into the work of the project, one that not only provides a real-time view of the work as it happens, but also contains the entire record of the process for each of the various editions published since 2006. The wiki used for the *NMC Horizon Report: 2014 Library Edition* can be found at library.wiki.nmc.org.

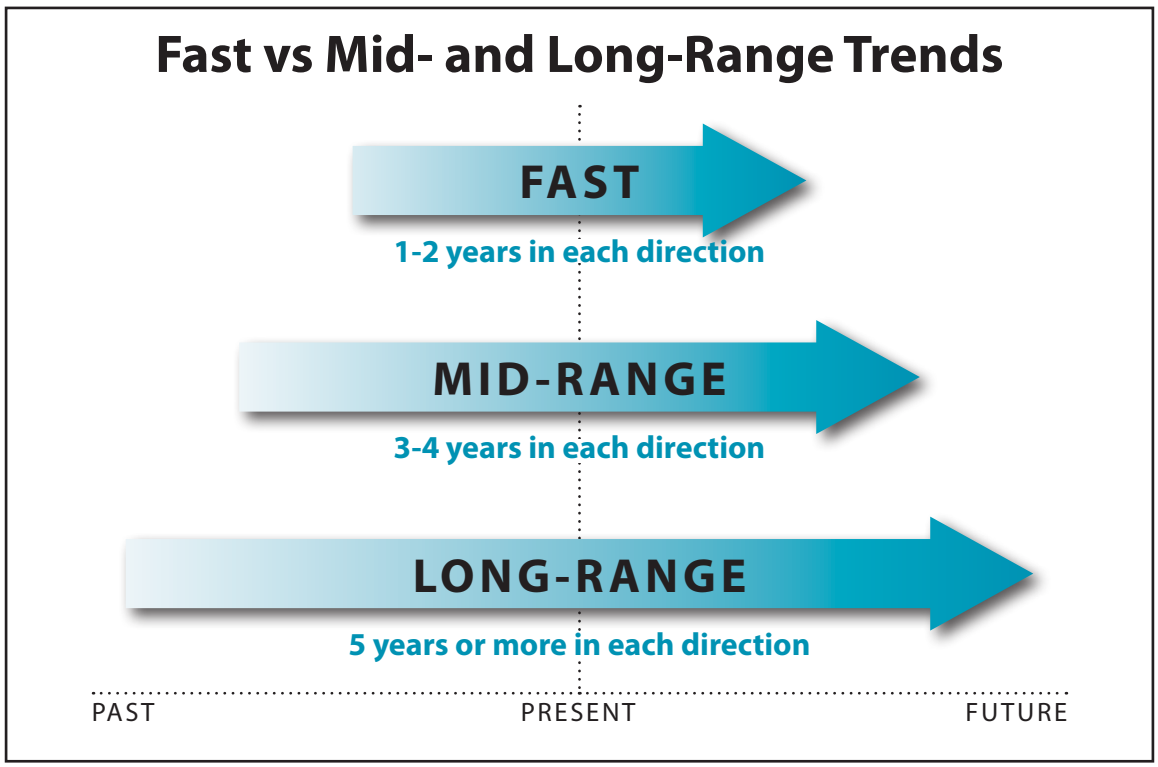
The panel was composed of 47 library and technology experts from 16 countries on five continents; their names and affiliations are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled technologies is going to have a significant impact on the evolution of academic and research libraries around the globe over the next five years. Also representing the experts' perspectives are the key trends driving interest in their adoption, and the significant challenges libraries will need to address if these technologies are to successfully see mainstream adoptions.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over 12 years of producing the *NMC Horizon Report* series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, nationalities, and interests, yet each member brings a relevant expertise. More than 1,000 internationally recognized practitioners and experts have participated on one or more panels since 2002. For any given edition, at least a third of panel members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the expert panel are encouraged; see go.nmc.org/horizon-nominate.

Once the panel for a particular edition is constituted, their work begins with a systematic review of press clippings, reports, essays, and other materials that pertain to the growth and evolution of emerging technology. Members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic in this edition is its potential relevance to academic and research libraries. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants.

Following this review, the expert panel engages in the central focus of the work — the organizing questions that are at the core of the NMC Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the panel:

Key Trends Model



1 What trends do you expect to have a significant impact on academic and research libraries worldwide within the next five years?

2 What do you see as the significant challenges that academic and research libraries worldwide will face over the next five years?

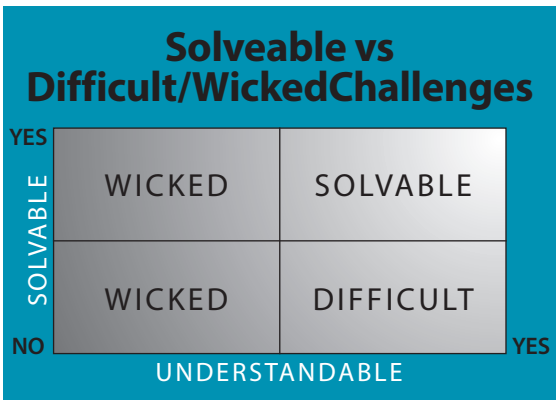
3 Which of the key technologies catalogued in the NMC Horizon Project listing will be most important to academic and research libraries worldwide within the next five years?

4 What key technologies are missing from our list? Consider these related questions:

- **What would you list among the established technologies that some academic and research libraries are using today that arguably all academic and research libraries should be using broadly?**
- **What technologies that have a solid user base in consumer, entertainment, or other industries should academic and research libraries be actively looking for ways to apply?**
- **What are the key emerging technologies you see developing to the point that academic and research libraries should begin to take notice during the next five years?**

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each expert panel member using a multi-vote system that allows members to weight and categorize their selections. These are compiled into a collective ranking, and inevitably, the ones around which there is the most agreement are quickly apparent.

Significant Challenges Model



From the comprehensive list of trends, challenges, and technologies originally considered for any report, the dozen that emerge at the top of the initial ranking process in each area are further researched and expanded. Once these interim results are identified, the group explores the ways in which these topics impact academic and research libraries. A significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to practitioners. For every edition, when that work is done, each of these interim results topics is written up as a preview. The topics in the interim results are then ranked yet again, this time in reverse. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2014 Library Edition*.

Trends Accelerating Technology Adoption in Academic and Research Libraries

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories — fast-moving trends that will realize their impact in the next one to two years, and two categories of slower-moving trends that will realize their impact within three to five or more years. A graphic in the Introduction on page 2 depicts the trend categories. All of the trends listed here were explored for their implications for academic and research libraries in a series of online discussions that can be viewed at library.wiki.nmc.org/Trends.

The NMC Horizon Project model established three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern libraries; leadership is the product of experts' visions of the future of library infrastructure and services, based on research and deep consideration; and practice is where new ideas and technologies take action, in libraries and related settings.

Policy. All of the identified trends had policy implications, but two trends in particular are expected to have a strong impact on policy decisions over the next five years. It is widely agreed that research data management for publications is becoming increasingly important for libraries. Major organizations such as the National Science Foundation are now mandating that all libraries that apply for grants include a viable research data management strategy in their proposals. The proliferation of this trend has spurred the Association for Research Libraries to develop a guide to help standardize the process.[4]

While the panel experts also believe that the trend toward increasing accessibility of research content will reach its maximum impact in academic and research libraries within three to five years, policy makers are already taking important actions to design effective protocol. For example, Penn State University has adopted an open access approach that is supported by Penn Compact 2020 and has drafted guidelines that will help the institution's resources reach more people outside of the campus. The initiative is being managed by Penn State Libraries.[5]

Leadership. Although there are leadership implications highlighted for all the identified trends as well, two trends stand out as unique opportunities for innovative vision. First, the evolving nature of the scholarly record is encouraging libraries to share information in new, enhanced formats. Leading library organizations are instigating critical discussions around this topic. The Association of European Research Libraries recently hosted a workshop that explored the future of scholarship, based on research conducted by the Online Computer Library Center (OCLC). The keynote presentation predicted the move from traditional journal systems to a "Web of Objects."[6]

The NMC Horizon Project model established three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice.

There is also a growing awareness that library technology, standards, and infrastructure need to be continually updated to keep pace with patron and researcher needs. Progress in this area requires leadership and resources that guide libraries through operational changes. In the UK, JISC has stepped into this role by launching their Digital Infrastructure Program. This initiative provides tips for libraries to develop effective digital preservation workflows and informs them of new technologies and processes that they can integrate into their infrastructure and services.[7]

Practice. Each of the six trends identified by the expert panel has numerous implications for academic and research libraries, and in many cases, current examples are easy to find. A widespread emphasis on mobile delivery has improved accessibility of library content for students, faculty, and researchers. Duke University Libraries, for example, has adopted the "BrowZine" app, which optimizes the displays for academic journals and other library resources across users' mobile devices.[8]

Finally, as industries such as architecture and biology are leveraging knowledge and skills from other areas to accomplish goals such as improving the sustainability of buildings and making breakthroughs in treatments for genetic diseases, new forms of multidisciplinary research are on the rise across academia. To promote and house this kind of work, dedicated spaces are emerging in libraries and on university campuses. At Brown University, the Institute for Molecular and Nanoscale Innovation is bringing together faculty from nine departments to make important discoveries about environmental health and the effects of nanotechnology.[9]

The following pages provide a discussion of each of the trends highlighted by this year's expert panel that includes an overview of the trend, its implications, and curated recommendations for further reading on the topic.

Increasing Focus on Research Data Management for Publications

Fast Trend: Driving technology adoption in academic and research libraries over the next one to two years

The growing availability of research reports through online library databases is making it easier than ever for students, faculty, and researchers to access and build upon existing ideas and work. Archiving the observations that lead to new ideas has become a critical part of disseminating reports. Enhanced formats and workflows within the realm of electronic publishing have enabled experiments, tests, and simulation data to be represented by audio, video, and other media and visualizations.[10] The emergence of these formats has led to libraries rethinking their processes for managing data and linking them between various publications. As a result, connections between research publications are crystalized, making it possible for researchers to discern how findings from one study have impacted another to get a better picture of how an idea has evolved over time, while exploring it from different angles. Advancements in digital data management are ultimately leading to more accurate subject search results and citations, and enabling libraries to more effectively curate and display relevant resources for patrons.

Overview

For many years, academic libraries have maintained online databases for faculty and students to locate books and research based on subject, keyword, and other searches. According to a recent article by the Ubiquitous Librarian in *The Chronicle of Higher Education*, some educators are finding that these databases are no longer as useful as they could be, particularly because students are spending too much time searching and not enough time reading.[11] Locating disparate resources for an assignment and trying to connect them with other relevant publications slows down the research process and has presented an opportunity for libraries to re-conceptualize data management and how that data is discovered. Libraries and information-focused organizations such as the European Library, the Library of Congress, Mendeley, CORE, and Elsevier Labs are convening workshops to investigate and create new tools for data mining scientific publications to identify patterns revealed in large sets of data that can lead to breakthroughs in the accuracy and efficiency of research.[12]

As universities and other learning-focused institutions generate more data over time, academic and research libraries are well poised to be the managers and curators of this information. Just as one would create a family tree to identify and depict the relationships between people, libraries are now in the unique position of illuminating the connections between research data from various studies and initiatives. By digitally archiving the datasets from every publication they contain, tagging them with metadata and keywords, and making them searchable, library databases can uncover links and patterns between studies, revealing the full trajectory of an idea as it grows. Bibliometrics tools, as discussed in the Important Developments in Technology section of this report, aid this process by quantifying the number of times a publication has been cited so that libraries can see the entire body of work that builds upon it.[13]

One of the most compelling facets of this trend is how it impacts the process of scholarly research. AKSW, a research group hosted by the University of Leipzig and the Institute for Applied Informatics in Germany, launched the project "Analyzing Cognitive Evolution Using Linked Data" to show how querying data that has been aggregated from various disciplines can answer complex questions related to cognition. This study involves linking data from the evolutionary history of genes to the types of diseases they have been known to cause — research that draws from a combination of genetics, biomedics, and other data areas. Ultimately, AKSW took 12 different datasets and integrated them into a single online database to demonstrate the improved efficiency with which cognitive diseases could be identified and understood by researchers.[14]

Implications for Policy, Leadership, or Practice

Major funding organizations such as the National Science Foundation (NSF) have recognized the role of effective data management in research initiatives by altering their library grant policies to mandate data management plans in all proposals submitted. As a result, the Association for Research Libraries has created a guide to help library professionals make sense of these regulations.[15] Aggregating research data from many sources into a single publication also requires extensive knowledge of the latest copyright and intellectual property laws. Resources for Research Ethics Education provides a list of regulations for libraries that include a range of research-

related topics, such as data management, the sharing of data, and publishing workflows.[16] The standardization of how authors and researchers are credited is essential to research data management. UMass Amherst Libraries provides guidelines for researchers with regards to re-distribution and citation rights, alternative licensing, and legal language for fair re-use.[17]

Visionary leadership for research data management models is also required to determine how to best incorporate data connections into library catalogs. The Harvard-Smithsonian Center for Physics and Astronomy is one good example; their SAO/NASA Astrophysics Data System, funded by NASA, contains 10.7 million scholarly records, and tracks citations and usage of their resources to "provide advanced discovery and evaluation capabilities."[18] Researchers at the Mannheim University Library and GESIS - Leibniz Institute for the Social Sciences in Germany published the paper "Integration of Research Data and Research Data Links into Library Catalogues" to investigate how an integrated search environment for publications and research data could better illuminate the relationships between various reports and papers. Their system leveraged a sophisticated metadata mapping process between existing library catalogs, but noted the challenges of overcoming the fact that the metadata is often data repository- or domain-specific. Each database and system of bibliographic records has a distinct way of categorizing publications and data, so there is a need for a tool that can efficiently interpret and standardize all sorts of metadata.[19]

As more and more research data is curated into publications and sophisticated databases, libraries have an opportunity to reimagine how patrons navigate and discover new information. The definition of a publication itself is evolving beyond the constraints of static text and charts to take on a format that is more interactive. The Johns Hopkins Milton S. Eisenhower Library houses a 2-meter by 4-meter visualization wall, "Balaur Display Wall," consisting of TV screens, which responds to users' gestures through Microsoft Kinect technology. Wall images represent curated datasets from the university on subjects including medieval manuscripts and star systems. For example, students can learn how to categorize galaxies by manipulating all of the star systems data on the visualization wall.[20] This kind of innovation is causing librarians, such as those at the University of Oxford Library, to consider new practices for publishing scientists' work, and how libraries can assist them through all of the stages of research — from collecting, labeling, and presenting this data to realizing how it can enhance existing datasets through visualizations. The head librarian at the Oxford Library envisions librarians becoming "co-contributors to the creation of new knowledge."[21]

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing focus on research data management for publications:

11 Case Studies Released on Research Data Management in Libraries
go.nmc.org/elev
(Association of European Research Libraries, accessed 16 July 2014.) Eleven case studies describe the policies, challenges, and strategies that have been a key part of the creation, institutional integration, managing of support services, and underlying infrastructures of library research data management solutions. > *Policy*

Research Data Management Principles, Practices, and Prospects
go.nmc.org/princi
(The Council on Library and Information Resources, November 2013.) This report discusses data management requirements of the National Science Foundation, National Institutes of Health, and other federal agencies and examines how research institutions are responding. > *Policy*

Ten Theses
go.nmc.org/tenthe
(Klaus Tochtermann, November 2013.) Ten theses describe factors that will shape scientific information infrastructure. One prediction is that technologies will allow researchers to perform less active searching for literature because related literature to their work and studies will be delivered to them proactively. > *Leadership*

Using Digital Technologies to Support Research: JISC Digital Festival 2014
go.nmc.org/tosupp
(The London School of Economics and Political Science, 17 March 2014.) The recent JISC Digital Festival covered research data management and ways to effectively meet the challenge of developing services that ensure researchers are supported in managing digital research outputs generated throughout their work. > *Leadership*

Re3Data
go.nmc.org/inqui
(Re3data.org, accessed 7 July 2014.) The goal of re3data.org is to create a global registry of research data repositories that connects ouputs and publications. > *Practice*

ScienceScape
go.nmc.org/scape
(ScienceScape.org, accessed 7 July 2014.) ScienceScape applies intelligent sorting algorithms to incoming new publications in order to build subscription-based feeds for collecting research. > *Practice*

Prioritization of Mobile Content and Delivery

Fast Trend: Driving technology adoption in academic and research libraries over the next one to two years

Mobile devices such as smartphones, tablets, and e-readers are capturing a larger share of the information market. A Pew Research Center study of American adults reported that 42% own tablet computers, 55% own a smartphone, and 50% have a handheld device dedicated to e-reading.[22] With this shift to mobile content consumption, patrons, faculty, researchers, and students are expecting access to library resources anytime and anywhere. To adapt to this growing demand, academic and research libraries are integrating mobile options for content and delivery into their services, including mobile-friendly versions of websites, apps, catalogs, and e-books.[23] Some libraries are furthering this trend by loaning devices such as tablets and e-readers to patrons, just as they would a printed book.[24] As the types of mobile devices and applications continue to evolve, libraries are becoming more focused on lasting solutions that are device-neutral.[25]

Overview

Since 2003, Elsevier's researchers have embarked on usability studies of academic and research library websites to determine the best way to organize content for users.[26] Although conducting research, searching course material, and locating user accounts and general library information still rank highly among critical features,[27] the manner in which an individual accesses this data has changed due to the rapid proliferation of mobile technology.[28] Academic and research libraries have implemented a number of solutions to accommodate mobile users, including the creation of mobile versions of their websites, native apps, and responsive web design.[29] All of these actions have streamlined full website content for optimization on smaller screen sizes. While the prioritization of mobile delivery has gained traction in libraries, the current debate concerns the most efficient way to serve the wide variety of mobile devices that are accessing their resources.[30]

The rise of mobile technology is also changing scholarly workflows; students and researchers increasingly prefer to search a library's catalog, read abstracts and full digital content, and find and save references through a library's mobile site or app rather than by visiting the physical facilities.[31] It is not only important to feature basic library information, but also to prioritize tasks that enable productivity for those conducting research via mobile devices. Optimizing library catalog searches for mobiles is one of the most useful features,[32] and the integration of library databases such as EBSCOhost,[33] JSTOR,[34] and WorldCat[35] into an academic library's mobile site or app makes for a robust tool for patrons searching for books and journal articles from one location on their mobile device.

With the increase in mobile access to digital materials, academic and research libraries are working to deliver older content to tablets and smartphones and distribute newer types of content such as e-books. Reading habits are changing with the uptake in mobile device usage due in large part to smaller screen sizes; this requires that content be formatted in a way that is easier for people to read.[36] While PDFs have been a common way to access digital content since the 1990s, they are better suited for desktops, laptops, and other large devices. Solutions such as delivering content in EPUB 3 format is seen as a viable option for reading on small devices.[37] Students and researchers also expect increased access to digital materials, including e-books, videos, and data visualizations on their mobile devices. To address this trend, academic and research libraries are working with vendors and publishers to distribute e-books, primarily through perpetual access and subscription models.[38] While copyright issues are hampering e-book access in Europe,[39] library consortia in the United States are working together to tackle another barrier to mobile content access — the inability to offer interlibrary loans of e-books.[40]

Implications for Policy, Leadership, or Practice

Libraries are beginning to develop policies on the use of mobiles in their facilities. Penn State University Libraries, for example, recognizes the growing importance of cell phones for daily life. The library has designated cell phone use zones to discourage the distraction of conversations.[41] Additionally, the need to update copyright policies to recognize mobile-friendly digital goods, such as e-books, is affecting libraries across the world. "The Right to e-Read" campaign by the European Bureau of Library Information and Documentation

Associations (EBLIDA) is a Europe-wide initiative to raise awareness for stakeholders and policy makers about the challenges libraries face in providing e-books and digital content because of copyright concerns.[42] Libraries in the United States are closely following the legal policies regarding the purchasing and resale of digital content. The First Sale Doctrine was established to make it possible to sell, lend, or dispose of a physical copy of a copyrighted work without permission from the copyright holder.[43]

Facilitating the movement towards mobile content and delivery requires leadership amongst library associations, professional development providers, and other academic and research libraries. The JISC Mobile Infrastructure for Libraries Programme, for example, established the "Mobilising Academic Content Online" project to develop a good practice toolkit that addresses the challenges involved in delivering academic content onto mobile devices.[44] Similarly, a recently-funded project at the University of California Davis will create a roadmap for strategic planning and investments in new software, standards, and expertise.[45] Professional development and other online resources are also currently available to bring librarians up to speed on understanding and developing mobile apps and sites. The American Library Association's TechSource offers information and training on how to improve a library's mobile website;[46] 23 Mobile Things is a self-paced online course that explores the potential of mobile tools for the delivery of library services.[47]

The prioritization of mobile content and delivery is reflected in many practice examples. At Duke University Libraries, they are using the "BrowZine" app for tablets to make library resources more mobile-friendly, enabling library patrons to browse, read, and monitor current academic journals.[48] The University of Exeter's library also emphasizes mobile content by providing a list of resources that can be accessed through mobile websites and apps. As mobile sites and device-specific apps grow in popularity, academic and research libraries are also providing device-agnostic solutions to access mobile content, such as responsive design. Websites at University of Toronto, Princeton University, ETH Bibliothek and University of Arizona libraries ensure that viewing can be optimized on any type of screen size, even those that have not been invented yet.[49]

For Further Reading

The following resources are recommended for those who wish to learn more about the prioritization of mobile content and delivery:

Pathways To Best Practice Guides
go.nmc.org/jiscin
(JISC, 23 August 2012.) These guides outline the benefits of mobile usage for libraries and present different ways to leverage mobile technologies to improve content delivery and other key library services. > *Policy*

An Academic Library Mobile App is Not a Technology of the Future: It's a Necessity for Connecting with Students in the Present
go.nmc.org/nece
(Megan Vizzini, Boopsie Blog, 4 April 2014.) The author explores one of the most prevalent education trends — ubiquitous learning. Library mobile initiatives can help put vital resources in the hands of students. > *Leadership*

Developing a Prototype Library WebApp for Mobile Devices
go.nmc.org/aria
(Cooper Brewerton, *Ariadne*, 10 June 2013.) Based on a review of Loughborough University Library's website traffic and statistics, the author provides recommendations for the creation of mobile-friendly web applications. > *Leadership*

Library Success: A Best Practices Wiki
go.nmc.org/m-li
(M-Libraries, accessed 16 July 2014.) This collaborative and regularly updated wiki compiles resources, tools, and examples of libraries that are offering mobile interfaces or applications. > *Leadership*

Mobile Strategy or 'Online' Strategy? An Introduction to Responsive Design
go.nmc.org/respo
(Toby Plewak, *Publishing Technology*, 22 July 2014.) There are many benefits of responsive web design for publishers, including the ability to fluidly maintain and update just one site while providing full functionality for all devices and screen sizes. > *Practice*

Mobile Web Interface of Academic Libraries (PDF)
go.nmc.org/mobint
(Hyejung Han and Wooseob Jeong, *asis&t*, accessed 30 June 2014.) The authors analyze academic library mobile websites to assess the services they provide, their user interfaces, and more effectively meeting user needs.
> *Practice*

Evolving Nature of the Scholarly Record

Mid-Range Trend: Driving technology adoption in academic and research libraries within three to five years

Once limited to print-based journals and monographic series, scholarly communications now reside in networked environments and can be accessed through an expansive array of publishing platforms.[50] The Internet is disrupting the traditional system of scholarship, which was founded on physical printing and distribution processes that no longer apply. Now scholarly records can be published as soon as peer review has taken place, allowing communication to happen more frequently and more publicly than ever before. No longer limited to text-based final products, scholarly work can include research datasets, interactive programs, complex visualizations, lab articles, and other non-final outputs as well as web-based exchanges such as blogging. There are profound implications for academic and research libraries, especially those that are seeking alternative routes to standard publishing venues, which are often expensive for disseminating scientific knowledge.[51] As different types and methods of scholarly communication are becoming more prevalent on the web, librarians will be expected to stay up-to-date on the legitimacy of these innovative approaches and their impact in the greater research community.

Overview

For creative disciplines, reaching an understanding of what comprises scholarly data has been a frequent point of discussion. In 2013, a team of researchers working on behalf of the Digital Curation Center published *Pinning it Down: Towards a Practical Definition of 'Research Data' for Creative Arts Institutions*, which aims to translate scientific research data management practices into a concrete definition for librarians and other professionals responsible for the scholarly records of creative disciplines. Based on interviews conducted with research professionals from the University of the Arts London (UAL), the researchers found that while their concept of data paralleled that of scientists in many ways, it could also encompass ephemeral experience such as the number of times an artist speaks publicly about their work and the creative process behind it. Although the researchers agreed upon a definition of research data for a creative arts institution such as UAL, they acknowledge that a toolkit will be required to support librarians at art institutions.[52]

Beyond discussions about novel forms of the scholarly record, there is also more focus on how the variety of publishing outlets have given rise to a more dynamic model of scholarship. In a recent editorial "Why Do We Still Have Journals?," a social sciences researcher highlights the opportunities offered by information technology that are providing scholars more choice in how they publish; each method of publication offers different affordances. Watson and Crick shared their discovery of the structure of DNA in 12 brief paragraphs, for example; today, their contribution could have been conveyed through a series of blog posts. The author of the editorial argues that as long as the journal's essential functions are maintained — certifying, convening, and maintaining scientific work — scholarship can move beyond the limitations of the traditional paradigm. The Internet and networked communities can be leveraged to incorporate a peer review process that ensures research is accurate and contributes to the greater goal of innovation.[53]

Among the emerging models is the mini-monograph, or mini-ebook, which offers researchers a method of publishing works that is between the length of a journal article and a typical monograph. Developed by Palgrave Macmillian in 2013, the Palgrave Pivot is a new digital-first research format that publishes within 12 weeks of acceptance post peer review.[54] This new format was envisioned as a response to academics seeking to publish work that does not fit the guidelines imposed by traditional publishing formats; indeed, in a small survey conducted by *The Chronicle of Higher Education*, many professors indicated their desire for more diversity in acceptable formats for scholarly work, especially for graduate students. Yet, some professors believe established scholars who adopt the new format early can lend it credibility to foster that acceptance.[55] Librarians play a crucial role in advancing these conversations with their knowledge of publication practices and can help to discern whether alternatives to traditional models are impactful enough to merit further use.

Implications for Policy, Leadership, or Practice

The Online Computer Library Center (OCLC) is sparking serious discussions among institutional leaders and librarians about the impact of this trend on the future of scholarship. Published in 2014 by the OCLC, *The*

Evolving Scholarly Record is an effort to address the changes inherent in digital scholarship as it evolves with technology. Their conceptual framework guides discussions about transforming scholarly records, defining the categories of materials it encompasses and the roles of key stakeholders involved. In addition to the framework, they pinpoint the distinction between scholarly record and cultural record; the mutability of digital materials, and how that will impact citation and referencing practices. They also include details on manifesting a scholarly work for discovery, access, and use, along with models of stewardship that will lead to long-term sustainability.[56]

The Association of European Research Libraries has taken the lead on this trend in the coordination of a workshop to share the implications of the OCLC's research on the evolution of scholarship.[57] During this event, scientist Herbert van de Sompel from Los Alamos National Laboratory presented a keynote explaining the fundamental changes the digital era has imposed on the nature of scholarship. One of the main takeaways is that the dynamic, public nature of the scholarly record is changing the paradigm from a journal system to a "Web of Objects" that will transform the way research librarians approach archival activities. These conversations are helping academic and research librarians increase their capacity to talk knowledgeably about these fundamental shifts to their administrators so they can better anticipate how expanding definitions and formats of the scholarly record are changing research practices and standards, now and far into the future.[58]

Some institutions have already coordinated research initiatives to stay ahead of the curve; the University of California Davis, for example, began the "Innovation in Scholarly Communication" project to identify the changes that are impacting traditional modes of publication and to unload the meaning of the term publication in the digital age. Funded by the University of California Davis Interdisciplinary Frontiers in the Humanities and Arts program, the initiative is a collaborative effort from the School of Law, the University Library, and the Genome Center to investigate three key issues: new models of scholarly communication, new misconduct and new opportunities, and communication with data.[59] Since November 2013, the project team has maintained a blog, posting about their research themes, including topics such as "The Bleeting Edge: Blog and Tweet or Perish" and how to obtain digital object identifiers for blog articles.[60]

For Further Reading

The following resources are recommended for those who wish to learn more about the evolving nature of the scholarly record:

Yale University Library Policy for the Digital Preservation (PDF)
go.nmc.org/yaleu
(Yale University Library, accessed 25 July 2014.) As scholarly records evolve, universities must continually update their digital preservation policies to reflect the types of objects being stored and the best practices for long-term accessibility. Yale's policy leaves room for flexibility. > *Policy*

Integrated Digital Scholarship Ecosystem
go.nmc.org/integr
(Canadian Research Knowledge Network, accessed 23 July 2014.) The Integrated Digital Scholarship Ecosystem is an initiative to advance research in Canada by understanding the complexity of the digital landscape as it relates to scholarship and by seeking opportunities to align key stakeholders and providers around a series of shared objectives. > *Leadership*

Online Scholarly Communications: Van De Sompel and Treloar Sketch the Future Playing Field of Digital Archives
go.nmc.org/scholcom
(Inge Angevaare, *Research in KB*, 22 January 2014.) Digitization means that the research process is becoming more exposed, objects are no longer static, and machines are joining humans as co-creaters of research objects. However, the scholarly record is not all digital; there are plenty of physical objects that must be archived as well. > *Leadership*

Ten Questions with the Library Publishing Coalition
go.nmc.org/tenq
(Meredith Schwartz, *Library Journal*, 2 April 2013.) This interview with founding members of the Library Publishing Coalition describes how the organization is progressing towards its goals of deeper collaborations among library publishers, and between library publishers and external partners. > *Leadership*

The Center for Digital Scholarship at Notre Dame
go.nmc.org/notre
(Notre Dame Library, accessed 24 July 2014.) Notre Dame launched its Center for Digital Scholarship in 2013 to advance the vision of redefining and transforming library services and spaces to fit the new demands of the modern scholarly record. > *Practice*

The "Digital" Scholarship Disconnect
go.nmc.org/disc
(Clifford Lynch, *EDUCAUSE Review*, 19 May 2014.) This article considers some of the challenges of this topic, such as data management and long-term funding for data resources. > *Practice*

Increasing Accessibility of Research Content

Mid-Range Trend: Driving technology adoption in academic and research libraries within three to five years

Academic and research libraries are gradually embracing the movement toward openness as the Internet has opened the floodgates of information and scientific knowledge. The open access movement has been an influential element of this trend, and it has a significant following in the library community among those who believe in removing financial and intellectual barriers for scholarly work. Major funding entities such as the UK's Research Excellence Framework, the National Science Foundation, and National Institutes of Health have implemented guidelines requiring researchers to include dissemination plans for their data along with their outputs, expanding access to encompass all scientific outputs.[61] [62] A number of libraries are opening up their institutional repositories, allowing the general public to access their research. Several journal publishers are meeting institutions halfway by developing novel payment schemes that are based on region or quantity of outputs. More collaboration is taking place between institutions as they work co-operatively to lower costs within the publication process.

Overview

While the open access movement is the most obvious manifestation of this trend, it is not the only way that academic and research libraries are working toward making their outputs more accessible. Widespread concerns about journal subscription fees have caused a number of major publishers to negotiate their costs, offering lower prices to smaller institutions and more flexibility to institutions with package deals.[63] More and more mainstream publishers, including Elsevier, are offering hybrid models in efforts to meet the needs of institutions that want to publish openly, on a per-article basis. Publishing through a hybrid model is technically open access, but publishers are paid twice in this circumstance because institutions pay the subscriptions and the authors pay to publish openly.[64] Many open access journals generate revenue by charging authors article processing fees (APCs) to cover the cost of online publication. While these costs can be lofty as well, *The Directory of Open Access Journals* reported that nearly two-thirds of OA journals listed do not charge APCs.[65]

High-profile projects have brought more attention to the ideal of a global, barrier-free research environment. European research institution CERN recently embarked on one of the largest scale open access initiatives in the world — SCOAP^3 — which involves more than 1,000 libraries, library consortia, and research organizations from 24 countries. The project is built around a partnership of 11 international journals that are working toward the shared goal of reducing subscription fees and increasing access for a collective of research institutions. The initiative has already opened up a large number of articles in the field of high-energy physics without charging APCs and has re-licensed them to be freely searched and used.[66] SCOAP^3 implements a model in which APCs are centrally supported, and its partner institutions contribute to the collective based on a sliding scale according to their country's share of research output.[67]

The trend toward expanding access has gained a disproportionate amount of traction in some regions of the world compared to others. In Latin America, researchers have been publishing publicly-funded research on open access platforms such as SciELO since 1998. Established with the goal of helping researchers increase their visibility and democratize access to scientific publications, SciELO garners an average of 1.5 million journal article downloads a day. While Peru and Argentina are the only countries in Latin America that have federal mandates in place for public research, the philosophy of open access is understood and practiced widely in this part of the world.[68] There are a number of other countries that have formalized their commitments to disseminating research produced with public funding including Australia, Austria, Canada, the European Union, India, and South Africa.[69]

Implications for Policy, Leadership, or Practice

Some universities have embodied the trend by creating institutional policies that encourage researchers to bypass journals and publish their research openly. Penn State, for example, gives the public free access to the Scholarly Commons, an online repository of over 20,000 papers from Penn State researchers. The university's move to openness was encouraged by the vision laid out by the university's president in the Penn Compact 2020, a set of guidelines focused on increasing access

to Penn State's intellectual resources to engage local, national, and global populations.[70] Managed by Penn State Libraries, the institution's researchers benefit from persistent URLs to archive and preserve their work online as well as analytics to optimize searches and track downloads. The knowledge-sharing project has received more than 6.6 million full-text downloads from around the world, which are tracked on an interactive map on the project's homepage.[71]

A number of organizations have been established to lead academic and research libraries in their missions to increase access to their scholarly outputs. Started by the Association of Research Libraries in 1998, SPARC is an international alliance of more than 800 institutions that helps its global body of members learn strategies to establish sustainable systems of open scholarship.[72] Established the same year as SPARC, the Public Knowledge Project (PKP) has also been instrumental among research institutions and academic libraries in their missions to increase access to scholarly research.[73] As of 2013, the PKP team reported that there are at least 24,000 journals across the globe that are using Open Journal Systems (OJS), PKP's open-source journal management system and publishing system, to some degree. More than 7,000 journals are publishing at least ten articles annually using OJS, and the majority are located in Latin America and the Caribbean.[74]

Academic and research libraries are adapting to this trend with the help of publishers that are finding creative ways to offset costs to universities. A recent agreement determined by IOP, Research Libraries UK, and the Russell Group of leading universities initiated a large-scale pilot project that tests an offsetting model with 20 UK research libraries. APCs from articles published during this 3-year period will be offset against the institutions' subscriptions and license fees. The sliding scale inherent in this model has been implemented to reduce subscription fees for all universities involved; as open access publishing grows, libraries will benefit from reduced prices, but at low levels the early adopters are in the position to be the primary beneficiaries, creating incentive to continue publishing openly.[75]

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing accessibility of research content:

NUI Maynooth Policy on Open Access to Research
go.nmc.org/nui
(NUI Maynooth Library, accessed 6 July 2014.) In Ireland, NUI Maynooth mandates that all research content and scholarly publications arising from research carried out at the university should be made available at the earliest possible date through the NUIM Open Access Repository. > *Policy*

Open Publishing Can Improve Access to Knowledge
go.nmc.org/impro
(Rebecca Lawrence, PMLive, 3 July 2014.) Several initiatives in publishing aim to improve data transparency and avoid publication bias. Many journals are collaborating to develop data policies to ensure that data are hosted in a suitable and stable location, with appropriate access controls. > *Policy*

Making Your Publications Open Access
go.nmc.org/yourpubs
(Diane Dawson, College and Research Libraries, October 2013.) The Budapest Open Access Initiative created a guide to help researchers and librarians make the transition to open access. > *Leadership*

Open Access at Duke University
go.nmc.org/dukeoa
(Duke University Library, accessed 2 July 2014.) Duke University encourages open access through a number of initiatives that researchers may opt in or out of, including a fund to help cover author fees of open access journals. > *Leadership*

Beyond Open Access for Academic Publishers
go.nmc.org/publish
(*Content Forward*, 15 May 2014.) This article discusses how open access models are being adopted more and will soon be the norm. The author argues that widespread adoption of these models will enable publishers to focus on other updates, including innovative ways to deliver content. > *Practice*

How One University Library (Successfully) Implements an Open Access Authors Fund (Video)
go.nmc.org/sage
(Sage, YouTube, 14 April 2014.) In this video, the Open Access Librarian at the Centre for Scholarly Communication at the University of Calgary shares best practices for open access scholarly research. > *Practice*

Continual Progress in Technology, Standards, and Infrastructure

Long-Range Trend: Driving technology adoption in academic and research libraries in five or more years

A recent survey of US academic library directors by Ithaka S + R revealed that libraries are shifting focus from building local print collections to providing remotely accessed online resources and guiding students and researchers through new discovery services. Indeed, a large majority of respondents believe that the importance of building local print collections has declined since the last survey was conducted in 2010.[76] With the transition from physical resources to electronic resources, and the need for new services to support them, libraries are required to frequently assess the state of their operations. A number of trends are driving this focus, including the proliferation of mobile devices, the move towards data resources as part of infrastructure, including changes in identity management, and the increasing importance of cross-institutional systems, such as web-scale discovery and resource sharing, cloud computing, and distributed storage.[77]

Overview

Resources and services are evolving at such an accelerated rate that academic and research libraries are experimenting with a number of solutions to keep their institutions relevant in the new mobile and social paradigm. As addressed in a fast trend in this report, libraries are increasingly accommodating mobile device users by optimizing their online content. Furthermore, libraries are updating their facilities to be configured around users instead of collections. At the University of Technology, Sydney, a state-of-the-art robotic library retrieval system will store 12,000 metal bins of books underground to increase the amount of study space for library users.[78] Similarly, the Hunt Library at North Carolina State University is maximizing its physical space for library visitors by offering a Makerspace, production studios, and large-scale visualization displays.[79]

A growing number of remodelling and building upgrades showcase the progress that academic and research libraries are making to modernize the physical infrastructure of their facilities. They are also embarking on cross-institutional collaborations and partnerships to explore how virtual resources can be organized and made discoverable. Libraries are increasingly sharing digital resources through online public access catalogs, federated searching, scholarly web portals, and web-scale discovery systems in order to provide greater access to the wealth of electronic resources available. The Ontario Digital Library Research Cloud is one such collaboration in which ten university libraries in Canada are using cloud technologies to house large volumes of digital content for cost-effective and sustainable preservation. This federation of universities will not only lower costs, but it will also enable them to use advanced text mining tools to work with large bodies of digital content. Libraries are also adopting web-scale discovery services that enable patrons to seamlessly conduct searches across local and remote content through a single point of entry; OCLC, EBSCO, ProQuest, and Ex Libris are some of the external online search services that they are using.[80]

Now that many libraries have had experience working with internal and external digital infrastructures, more collaboration between international groups is occurring. The Aligning Repository Networks meeting in March, 2014 was the first of its kind, convening several major regional networks from Australia, Canada, China, Europe, Latin America, and the United States. This alignment of global networks will enable the exchange of data, improve access to content across regions, and allow greater accessibility to the products of research. During the event, delegates identified key actionable items that they will address together including adopting best practices for metadata standards, vocabularies, and services.[81]

Implications for Policy, Leadership, or Practice

As academic and research libraries provide access to a growing volume of digital materials, formal methods of authentication are needed. EDUCAUSE defines identity management as the policies, processes, and technologies that establish user identities and enforce rules about their access to digital resources.[82] This authorization process is not new, but as libraries connect multiple organizations together through cross-institutional systems, a new federated identity management system has emerged which extends these permissions and streamlines access to assets while protecting resources. The Coalition for Networked Information is continually engaged in issues related to infrastructure development and is currently working to formalize standards and policies regarding

federated identity management for supporting research across multiple campuses.[83]

Technology grants through government funding are also helping libraries keep pace with the changing digital landscape as new policies in the US,[84] Canada,[85] and Germany[86] are requiring libraries to more effectively manage research data. The European Commission's Horizon 2020 program is one large-scale project that is providing 15 billion Euros in funding for research and innovation activities across the continent. This funding will help shape e-infrastructures for individual libraries and give them the opportunity to embed themselves in regional research infrastructure.[87] Leaders also need to support the tools and services needed to connect researchers with academic resources. Through their Digital Infrastructure Program, JISC focuses on providing this type of guidance through digital preservation and curation, resource discovery, and emerging opportunities.[88]

Many academic and research libraries, such as the Morris Library at Southern Illinois University,[89] New York University,[90] and Weston Library at the University of Oxford[91] have upgraded their technology offerings through facility renovation and reconstruction. Other major projects are underway to enhance digital infrastructures; CORAL, the Centralized Online Resources Acquisitions and Licensing electronic management system created by the University of Notre Dame, is open-source software that features a series of interoperable modules for managing the life cycle of electronic resources from acquisition to usage.[92] The Association of Research Libraries was awarded a grant for their Shared Access Research Ecosystem notification service that provides a structured way to manage digital assets by reporting new research releases in a timely and comprehensive manner.[93] Cornell University Library, Stanford University Libraries, and Harvard Library Innovation Lab were also recently awarded a large grant to develop a linked data project. Their goal is to create a system that extracts information from existing silos and displays it in a format that is easily accessible and understandable.[94]

For Further Reading

The following resources are recommended for those who wish to learn more about continual progress in technology, standards, and infrastructure:

Promoting Interoperability: Working on Rights
go.nmc.org/rights
(Emily Gore, Digital Public Library of America, 3 March 2014.) The Digital Public Library of America recently teamed up with Europeana and Kennisland to promote global interoperability of their metadata. > *Policy*

The Wellcome Library Preservation Policy for Materials Held in Collections
go.nmc.org/wellc
(Gillian Boal and Dave Thompson, *Wellcome Library*, 2014.) The Preservation Policy for the Wellcome Library in London provides a comprehensive statement on the preservation and conservation of the Library's collections. > *Policy*

Global Alliance Focused on Responsible Data Sharing Shows Progress in Standards Development and Membership at First Partner Meeting
go.nmc.org/geno
(Broad Communications, 4 March 2014.) The Global Alliance for Genomics and Health aims to enhance sharing and interpretation of genomic and clinical information and build on existing work, best practices, and approaches. > *Leadership*

Refocusing our Efforts: Why Have a Digital Initiatives Program
go.nmc.org/refo
(Terry Reese, The Ohio State University, 26 September 2013.) The Ohio State University Libraries is examining their digital initiatives program and identifying the core business functions necessary to support the libraries' digital programs. > *Leadership*

College Libraries Transition to High-Tech Learning Centers
go.nmc.org/transi
(Steve Zurier, *EdTech Magazine*, 8 May 2013.) Many students come to campus today with multiple devices, including phones, tablets, notebooks, and MP3 devices. Bandwidth is of utmost importance for supporting media-rich activities. Libraries are now hosting workshops on how to use research and creative tools and software. > *Practice*

Grand Valley State University Technology Showcase
go.nmc.org/gvsu
(Grand Valley State University, accessed 25 July 2014.) The Mary Idema Pew Library Learning and Information Commons at GVSU highlights a variety of technologies that have applications across campus, including the Internet of Things, mobility, wearable computing, and robotics. > *Practice*

Rise of New Forms of Multidisciplinary Research

Long-Range Trend: Driving technology adoption in academic and research libraries in five or more years

According to the Melbourne Sustainable Society Institute, multidisciplinary research refers to concurrent exploration and activities in seemingly disparate fields.[95] Digital humanities and computational social science research approaches are opening up pioneering areas of multidisciplinary research at libraries and innovative forms of scholarship and publication. Researchers, along with academic technologists and developers, are breaking new ground with data structures, visualization, geospatial applications, and innovative uses of open-source tools. At the same time, they are pioneering new forms of scholarly publication that combine traditional static print style scholarship with dynamic and interactive tools, which enables real-time manipulation of research data. Applying quantitative methods to traditionally qualitative disciplines has led to new research categories such as Distant Reading[96] and Macroanalysis[97] — the study of large corpuses of texts as opposed to close reading of a few texts. These emerging areas could lead to exciting new developments in libraries, but effective organizational structures will need to be in place to support this collaboration.

Overview

This trend reflects a larger movement in society as all different industries are converging. The contemporary workforce is inherently multidisciplinary in that a diverse range of skills is needed for a person to be successful in their position. In academia, advocates of STEAM (science, technology, engineering, arts, and mathematics) programs in education emphasize the role of creativity in the mastery of key science and IT skills.[98] The architecture industry exemplifies the marriage of these seemingly disparate disciplines; today a measure of a well-designed building is the extent to which the infrastructure is environmentally friendly. U.S. LEED certifications recognize buildings that are energy- and water-efficient, made with sustainable materials, and accessed by a variety of transportation modes.[99] As such, the LEED program requires multidisciplinary knowledge that taps into a variety of subjects, including urban planning, renewable energy, and architecture.

In a similar manner, the emergence of Makerspaces in university libraries is bringing together students and researchers across a range of disciplines to showcase what they have learned through creating and 3D-printing models.[100] Library Makerspaces have been enabling students at the London School of Fashion, for example, to prototype their artistic designs while gaining important technology skills.[101] More institutions are formally recognizing these kinds of efforts and are even developing platforms for the dissemination of multidisciplinary work. At Rutgers University, the new Aresty Research Symposium calls for students to present on their multidisciplinary work using multimedia and visualizations. At the inaugural April 2014 event, 530 Rutgers students shared their research, including the project "Communication Matters: The Significance of Patient-Physician Communication About Exercise for Older Breast Cancer Survivors," which identified the need for physicians to more explicitly recommend exercise to patients post-treatment to boost recovery rates.[102]

Key to promoting multidisciplinary research is demonstrating how various disciplines can work together to illuminate new information. For example, scholars are exploring scientific strategies that can condense vast amounts of literature into patterns that can reveal new relationships and concepts. Franco Moretti from the Stanford Literacy Lab published a theory called Distant Reading, which posits that people can comprehend literary texts by aggregating and analyzing large datasets about them. The Lab tested this idea by inputting 30 novels into computer programs that analyzed grammatical and semantic signals, along with word frequency. This work uncovered hidden aspects of plots by graphing them as networks, which has opened new doors to rethinking the study of literature and how libraries can play a role in the interpretation of the vast amounts of text they house digitally.[103]

Implications for Policy, Leadership, or Practice

Effective policy and infrastructure needs to be in place to facilitate the collaborations between departments that are needed to promote multidisciplinary research. Library and university leaders can look to the University of Toronto Governing Council and their report, *Policy on Interdisciplinary Education and Research Planning*, for examples of institution-wide strategy for creating guidelines and assessments. During this process,

checklists were developed to direct administrators and faculty through the process of launching interdisciplinary and multidisciplinary research projects, which include determining the implications for the library and incorporating them into the preliminary strategies.[104] In Belgium, Ghent University created a strategic research policy plan that awards grants based on the projects' incorporation of multidisciplinary collaboration.[105]

Several institutions are leading the way by formally establishing dedicated programs that prioritize cross-department efforts and scholarship. The University of Notre Dame, for example, launched the Multidisciplinary Research Committee, which develops projects and events such as "Promoting Multidisciplinary Research: Creating Interactive Spaces" in order to share best practices throughout the campus. As an addition to Hesburgh Libraries, their planned Multidisciplinary Research Buildings will be equipped with spaces that foster collaborations between students and faculty from different disciplines.[106] The Norwegian Research School in Medical Imaging is also developing a research training network that joins together innovation centers, libraries, hospitals, and other universities with the mission of cultivating a genuinely multidisciplinary approach within the field.[107] Similarly, in the Walters State Community College's Multidisciplinary Research in Applied Sciences program, students are trained in conducting multidisciplinary research.[108] Academic libraries are increasingly expected to store this kind of research and make it readily accessible to students and faculty; Old Dominion University Library, for example, provides links to 80 multidisciplinary databases.[109]

More and more, this multidisciplinary research is taking place in specialized research centers and libraries on university campus. The Institute for Molecular and Nanoscale Innovation (IMNI) at Brown University exemplifies multidisciplinary research in practice. In order to gain a more well-rounded perspective of the subjects, faculty from nine different departments are using their diverse skillsets and resources to explore fundamental phenomena, technologies, and the environmental health and societal impacts of nanotechnology. IMNI projects range from the development of lightweight materials for automobiles to the creation of sustainable carbon dioxide feedstock for various chemicals.[110] At Florida State University, the Institute for Digital Information and Scientific Communication partnered with the US Department of Defense (DOD) to establish the Military Suicide Research Consortium, the first ever civilian-DOD multidisciplinary effort to identify effective suicide prevention techniques and programs.[111]

For Further Reading

The following resources are recommended for those who wish to learn more about the rise of new forms of multidisciplinary research:

Study on the Legal Framework of Text and Data Mining
go.nmc.org/framew
(European Commission, March 2014.) Research is relying more on data analysis, which raises legal issues related to privacy and personal data protection. A few countries in the world have adopted or are in the process of adopting specific copyright provisions to introduce a data analysis exception in their legislation. > *Policy*

The Chancellor's Discovery Fund for Multidisciplinary Research - FY2014 Competition
go.nmc.org/discfund
(University of Illinois at Chicago, accessed 10 July 2014.) The program seeks to cultivate relationships between different kinds of researchers, with each bringing their own distinctive disciplinary perspectives to create solutions to societal challenges. > *Leadership*

Privacy Tools for Research Data
go.nmc.org/priv
(Harvard University, accessed 9 July 2014.) Harvard University is behind a broad, multidisciplinary effort to help enable the collection, analysis, and sharing of personal data for research in social science and other fields while providing privacy for individual subjects.
> *Leadership*

Terra Nova: The Australian Climate Change Information Hub
go.nmc.org/terra
(Terra Nova, accessed 9 July 2014.) This joint initiative between Griffith School of the Environment and eResearch Services, the Queensland CyberInfrastructure Foundation, and the Australian National Data Service, addresses research infrastructure needs for investigations into climate change adaptation research.
> *Leadership*

Now You Can Print 3D Models of Your Internal Organs
go.nmc.org/nowyou
(Mark Strauss, *io9*, 3 July 2014.) The National Institutes of Health launched 3D Print Exchange, a website that allows users to download, edit, and share models of anatomy, bacteria, and lab equipment. > *Practice*

Spatial Humanities
go.nmc.org/spat
(Scholars Lab, accessed 9 July 2014.) Spatial Humanities is a project that brought together cultural heritage workers, software developers, and scholars for intensive training, conversation, and collaborative work in GIS and spatial technologies for the humanities. > *Practice*

Challenges Impeding Technology Adoption in Academic and Research Libraries

The six challenges described on the following pages were selected by the project's expert panel in a series of Delphi-based cycles of discussion, refinement, and voting; the expert panel was in consensus that each is very likely to impede the adoption of one or more new technologies if unresolved. A complete record of the discussions and related materials were captured in the online work site used by the expert panel and archived at library.wiki.nmc.org/Challenges.

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The NMC Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well-understood but for which solutions remain elusive; and wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will even be possible. This challenges model is depicted by graphics in the Introduction on page 3. Once the list of challenges was identified, implications for policy, leadership, and practice were recognized.

Policy. While all of the featured challenges have important policy implications, two specific challenges are currently driving policy decisions in academic and research libraries. According to the panel, capturing and archiving the digital outputs of research as collection material is categorized as difficult. Important policy discussions, however, are already underway; the OCLC Research Library Partnership Data Curation Policy Working Group is addressing how libraries and universities can work together to coordinate and uphold research data management protocol. They are creating standards for preventing copyright issues, helping researchers to meet deposit requirements, and supporting increased access to research.[112]

Still far away from being solved is the wicked challenge of maintaining ongoing integration, interoperability, and collaborative projects in a constantly evolving landscape. Academic and research libraries must make frequent choices about what new strategies and technologies to adopt, so effective policies can help guide those decisions. Recently, the Confederation of Open Access Repositories joined several open access organizations to standardize technical interoperability, policies, and services. Together they plan to develop a network that enables research to contribute to and access a repository of aggregated data.[113]

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge.

Leadership. Leadership implications are common to all the challenges described in this section, but two will require visionary leadership. The first is considered by the expert panel as a crucial need to rethink the roles and skills of librarians — a transformation that is vital for the success of academic and research libraries. A solution is underway at the Harvard Law School Library, which is working with the Berkman Center for Internet & Society to create a new library staff position that will support teaching, learning, and curriculum at the library. The academic technology project manager is envisioned to support a suite of open-source online classroom tools that will be leveraged by university faculty.[114]

The second opportunity for extraordinary leadership was deemed a wicked challenge by the expert panel. Libraries are still trying to understand how they can most effectively embrace the radical changes needed to remain relevant, and are realizing that an attitude shift is required for solutions to take root. The Woodward Library at the University of British Colombia is merging their circulation and references services, so the staff drafted the *Strategic Plan* to make this transition smoother. In the plan, the library commits to a democratic process in which the staff determines new roles and responsibilities as a team.[115]

Practice. Each of the six challenges identified by the expert panel presents numerous impediments for academic and research libraries. Embedding libraries into higher education curriculum is classified as a solvable challenge, as it is already a priority for many institutions across the world. For example, the University of Bamberg Library in Germany developed curriculum for students to master skills such as database searching and reference management in addition to providing them with online tutorials that cover publication workflows and making proper citations.[116]

The second challenge is classified as a difficult one. The rise of alternative avenues for information discovery, such as Google Scholar, are providing competition to academic and research libraries. To solve this challenge, libraries must be able to facilitate opportunities that online services cannot, such as hands-on technology training and professional development. Georgetown University Library offers workshops where students and faculty can gain new skills in key areas such as video production and editing and data visualization tools.[117]

The following pages provide a discussion of each of the challenges highlighted by the expert panel that includes an overview of the challenge, its implications, and curated recommendations for further reading on the topic.

Embedding Academic and Research Libraries in the Curriculum

Solvable Challenge: Those that we understand and know how to solve

While libraries often provide general support to institutions, it is a challenge for librarians to make the case to faculty and curriculum committees that they should play a critical role in the development of information literacy skills. Ideally, instruction about information should occur at various points in a student's career, and there can be a variety of approaches including online tutorials for basic skills, one-time classes, in-depth classes/workshops on strategies and tools for specific disciplines, and classes focused on information policy issues, such as intellectual property. Librarians need to broaden their own concept of their role in the design of curriculum and provide outreach to faculty to help them understand how librarians can add to the education of students.

Overview

In *New Roles for New Times: Transforming Liaison Roles in Research Libraries* by the ARL, the authors state that research librarians should be engaged liaisons that understand and support all processes of instruction and scholarship. This requires libraries to move beyond offering freshmen writing programs and one-time guest lectures to collaborating with faculty on the development of online instructional material for courses, along with providing students with continuous library research skills support.[118] At the Indiana University-Purdue University Indianapolis Library, subject liaisons facilitate faculty and student research, engage with information literacy instruction and assessment, and develop collections to support the curriculum; they have dedicated support staff for dozens of subjects ranging from anthropology to chemistry.[119] Although these types of services are important and emerging on campuses, there are a number of challenges impeding widespread solutions.

Time management has been cited as a major obstacle to embedding libraries in the curriculum.[120] Promoting information literacy is a priority of an academic and research library, but it is thought to be a responsibility that should be shared with faculty across the university. Providing these types of services is time-intensive for librarians who want to work one-on-one with faculty members to co-teach a class, for example. Faculty also have limited time to develop these kinds of partnerships, even if they are willing to put in the effort.[121] Another barrier librarians face is in directly working with students. A study from Thompson Rivers University in Canada revealed that the lack of formal policies on the integration of information literacy in coursework is impeding progress in this area. They found that the individual faculty perceptions and attitudes about the importance of information literacy are critical to the success of library initiatives.[122]

If librarians choose not to teach the courses themselves, then other opportunities are available. A whitepaper from the Association of College and Research Libraries argues that in order for information literacy to be embedded in the curriculum and reach the largest possible number of students, librarians must train and assist faculty in teaching it in their courses.[123] A "teach the teacher" approach requires faculty to acknowledge that information literacy should be a core component of their course, includes faculty training on the use of information systems and how to develop it in their students, instills librarian commitment to faculty education, and transforms the library space into a physical and virtual learning environment. This challenge is solvable because both librarians and faculty already understand that it will require extensive coordination between both groups.

Implications for Policy, Leadership, or Practice

Formal policies can help foster a stronger relationship between librarians and faculty members to ensure that information literacy skills are embedded within the curriculum. The Council of Australian University Librarians has created standards and guidelines for developing information literacy skills throughout the nation's university community. They outline which information literacy activities can be planned, presented, and promoted.[124] Similarly, the London Metropolitan University has enacted a literacy policy that requires the participation of all academic staff and librarians to collaborate on integrating information literacy across the curriculum. The library is encouraged to actively seek opportunities to collaborate with faculty to introduce, develop, and evaluate information literacy as a core component of curriculum and work with external partners such as the Society of College, National and University Libraries, Consortium of National and University Libraries, and Chartered Institute of

Library and Information to maintain and develop their programs.[125]

Developing best practices and professional development courses are two ways that library leaders can overcome this challenge. Information literacy models such as Big6, Seven Pillars of Information Literacy, Information Search Process, and the PLUS Information Skills Model help guide librarians and faculty on teaching research processes.[126] At Grand Valley State University in Michigan, the library has also developed a guiding document that outlines information literacy core competencies. Faculty can use this information to collaborate on assignment creation, coordinate syllabi, provide a framework for workshops, create assessments, and increase the transparency of information literacy.[127]

The potential for further embedding the library into course curriculum is already being explored by a number of institutions. At the Merrill-Cazier Library at Utah State University, the staff uses a course and curriculum-integrated method to information literacy by working closely with faculty to customize instruction in general education and within specific majors. The sequenced approach begins in a first and second year composition course and then culminates at the senior level in more discipline-specific learning experiences across different majors.[128] Librarians at Centralia College in Washington support faculty through a number of services, including creating exercises and research guides for course integration, instruction sessions, online tutorials related to course content, and integrating a librarian in an online course.[129] The University of Bamberg Library in Germany has not only created curriculum for students in database search, Internet search, and web-based reference management, but also provides online tutorials on the cycle of publications and information, conducting efficient searches, and citations and references.[130]

For Further Reading

The following resources are recommended for those who wish to learn more about embedding academic and research libraries in the curriculum:

A New Approach to Needs Assessment and Communication to Connect and Collaborate with Faculty
go.nmc.org/ual
(Special Libraries Association, accessed 9 July 2014.) This paper describes how the University of Arizona developed a scalable and systematic method to conduct both needs assessment and communication for the whole library outside of a traditional liaison model.
> *Policy*

Benefits of Librarian-Faculty Partnerships for Instruction
go.nmc.org/maryl
(University of Maryland Library, accessed 11 July 2014.) The University of Maryland encourages librarian-faculty partnerships to help integrate information skills into university courses so students will not be daunted by the massive amount of resources available to them in the library. > *Leadership*

MIT Professor and Librarian Collaborate on "10 PRINT"
go.nmc.org/tenprint
(MIT Libraries, 9 January 2013.) MIT Press published a free e-book that explores different aspects of culture, from literature and religion to a programming language, through the lens of one specific line of code. The book is a collaborative effort between an associate professor of digital media and a librarian. > *Leadership*

Accessing, Evaluating, and Using Information: Report on Information Literacy at the U.S. Naval War College, 2014
go.nmc.org/nav
(Gina Brown et al., U.S. Naval War College, 2014.) The reference librarians at the Naval War College use a mix of workshops, new student orientation sessions, individual reference appointments, small group bibliographic instruction classes, faculty workshops, and multimedia subject guides called "LibGuides" to expand and support information literacy. > *Practice*

I Don't Have Time to Teach That: The Benefits of Faculty-Librarian Collaborations
go.nmc.org/dont
(Andrea Gillaspy-Steinhilper, *Instructional Design*, 16 July 2012.) This article describes how Lower Columbia College has integrated critical thinking and information literacy across the curriculum by bringing librarians into the classrooms to lead sessions on topics such as source evaluation and creating video casts. > *Practice*

The Liaison Program at the University of North Carolina Greensboro
go.nmc.org/liai
(University of North Carolina Greensboro Library, accessed 11 July 2014.) The Liaison Program assigns a professional librarian to each university department who works as an assistant to the faculty by collaborating with them for specific research needs, alerting the faculty to library services and policies, and communicating concerns between faculty and the libraries. > *Practice*

Rethinking the Roles and Skills of Librarians

Solvable Challenge: Those that we understand and know how to solve

As more universities incorporate new technologies into teaching and learning, there is an increasing demand for technological and instructional support for faculty and students. Libraries are uniquely situated to meet those needs. These evolving expectations are leading libraries to rearrange their organizations, resulting in the creation of new departments, new positions, and new responsibilities for library professionals. A seminal analysis of ARL staffing requests for 113 universities in the United States and Canada found that more than half the advertised positions were for newly created or significantly redefined roles.[131] While new roles are being created in traditional library areas, there is a clear hiring trend that emphasizes finding more functional specialists that have a strong digital or technology background. Academic and research libraries are being approached from many different directions and are expected to fulfill new and more specialized capacities. The challenge is in keeping institutions flexible enough to adapt to these new roles while finding leaders that can build sustainable models and collaborate across departments to meet the ever-changing needs of their institutions.

Overview

Academic and research librarians' roles have evolved beyond collection management and reference desk duties into that of subject specialists who provide discipline-specific research assistance to academic units in an institution. Increasingly, library staff interact with faculty and students, reinforcing the skills they need to become productive scholars and engaging them throughout the entire process of learning and research. Rapidly advancing tools, research methods, and pedagogies are challenging library staff to meet the expectations of their specified discipline while recognizing opportunities for further development and innovation. This has sparked the need for "superliaisons," or library staff that assist a variety of departments with their specialized skillset — an emerging role outlined by the *New Roles for New Times* report from the ARL. A superliaison may have expertise in copyright and open educational resources, online learning, media production, instructional design, or bioinformatics, among other areas.[132]

At the same time, academic and research librarians are also expected to become more involved in the campus-wide curriculum in an instructional context. Faculty that are incorporating media-based assignments into their courses are relying more on libraries to help students learn media production skills, but one-off workshops may not be adequate methods of training. Universities are increasingly expecting libraries to undertake more responsibilities in programmatic and teaching contexts, but librarians may lack the pedagogical background to design and facilitate a sustainable course. Information literacy is also gaining importance as the infrastructure of research continues to evolve, and researchers must learn to navigate these arenas with confidence. However, research librarians have observed that instruction has always been secondary if non-existent for library and information science graduates. They cite surveys that demonstrate new librarians leave feeling unprepared to teach and on-the-job training is the primary means by which they learn.[133]

As bibliometric and citation technologies become more advanced, and institutions more capable of discovering and optimizing their scholarly impact, administrators are expecting librarians to deepen their understanding of the analysis and preservation of research. In 2012, Research Libraries UK (RLUK) surveyed 23 of their member institutions in efforts to map the needs of the changing scholarly landscape and to create a series of recommendations for stakeholders. The RLUK study revealed that the skills of librarians, information specialists, and liaison staff must be developed to adequately support their institutions' researchers; subject librarians, specifically, will need to fulfill a role that has transformed from information discovery and management, collection development, and literacy training to one that emphasizes the research process in greater depth, from the curation and preservation of research data to mastering effective methods of scholarly communication and dissemination.[134]

Implications for Policy, Leadership, or Practice

Policy makers at every level can use emerging research about this challenge to anticipate the demands of academic and research libraries as they evolve. A noteworthy research effort has been made by the ARL

in the *New Roles for New Times* report, which outlines six trends in the changing role of librarians based on a thorough survey of organizational practices among five distinct ARL institutions. Libraries are adapting as quickly as they can to manage changing expectations, and the key is collaboration; examples are provided of how administrators and library leaders are working together to develop partnerships with other campus units.[135] The library at the University of Minnesota, for example, was tasked with managing the creation of a digital coursepack, a pilot project intended to streamline course content for faculty and students and make learning materials more affordable; the process required the library to establish working relationships with the copyright permissions center, campus IT, and the campus bookstore to create an effective project protocol.[136]

While universities are slow to adapt overarching policies to create the desired positions, there are some research libraries that are setting precedence in this area through dynamic partnerships. The Harvard Law School (HLS) library, for example, has collaborated with the Berkman Center for Internet & Society on the development of the academic technology project manager position that is based in the Teaching, Learning, and Curriculum team at the library. This new role is focused on providing support for an innovative suite of open-source, online classroom tools called H2O that are being used by the law school's faculty. The project managers will provide feedback and ideas to H2O's developers at the Berkman Center. Constant contact with faculty and students about the digital learning tools is keeping HLS library's services on the cutting-edge and providing opportunities for innovation.[137]

Hiring practices are changing as library managers and administrators endeavor to close the skills gap and broaden their capacities. A number of universities have experimented with fellowship programs and other non-permanent hiring situations that bring in people with the desired skills to work on discipline-specific projects. This strategy provides libraries the opportunity to test new types of professionals and see if their roles merit the creation of a new position. MIT Libraries is seeking a Library Fellow for a two-year term to help expand their research data management services and to collaborate with the Office of Scholarly Publishing, Copyright, and Licensing to help MIT researchers comply with open access avenues for research data.[138] North Carolina State University,[139] Emory University,[140] Purdue University,[141] and the University of Minnesota are implementing similar programs.[142]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking the roles and skills of librarians:

Do Librarians Need Tenure? Depends on Which Ones You Ask
go.nmc.org/tenu
(Sydni Dunn, *The Chronicle of Higher Education*, 12 November 2013.) East Carolina University has joined a growing list of higher education institutions that have changed their library models to no longer offer tenure to their librarians. > *Policy*

Research Support through the Lens of Transformation in Academic Libraries with Reference to the Case of Stellenbosch University Libraries
go.nmc.org/transfo
(Reggie Raju and Lucia Schoombee, LIASA, 2013.) This paper examines academic libraries to establish the deeper meaning of the librarian for the researcher and the research process. > *Leadership*

Training the 21st Century Library Leader
go.nmc.org/training
(Katherine Skinner and Nick Krabbenhoeft, *Meta Archive*, 9 May 2014.) This report is the first deliverable from the Nexus project, a planning project funded by the IMLS to evaluate the current state of library leadership programs and recommend cross-sector synergies and opportunities. > *Leadership*

Five Ways Academic Libraries Support Higher Education's Reboot
go.nmc.org/fivew
(Steven Bell, *The Evolllution*, accessed 9 July 2014.) Librarians are well-poised to help university faculty and students adapt to major infrastructural changes that are currently taking place in higher education. > *Practice*

Instructional and Research Technologies Librarian
go.nmc.org/instru
(Loyola University New Orleans, accessed 23 July 2014.) The new Instructional and Research Technologies Librarian position at the J. Edgar & Louise S. Monroe Library at Loyola University New Orleans works with professors to integrate technology-based assignments. > *Practice*

Rethinking Roles: Librarians and Faculty Collaborate to Develop Students' Information Literacy
go.nmc.org/roles
(Dianne VanderPol, *Library Innovation Journal*, 2013.) This article describes how the librarians at Westminster College led a faculty and staff learning community to help integrate information literacy into university courses. > *Practice*

Capturing and Archiving the Digital Outputs of Research as Collection Material

Difficult Challenge: Those that we understand but for which solutions are elusive

One of the essential purposes of academic and research libraries has been to collect the outputs of academic research.[143] Traditionally this has consisted of collecting textual, audio, video, and image-based outputs. With the introduction of new digitally-generated materials and processes, research outputs are growing in variety and types of format. It is important for these new digital data sets to be preserved alongside the research derived from them for future use and in longitudinal studies, but this presents a perpetual challenge for library acquisition and archiving practices as formats continue to evolve. The shift to new materials and processes has not only affected how material is captured and archived, but also how it is accessed and retrieved by other researchers and the general public. Compounding the challenge is that some large funders are requiring researchers to increase transparency and to develop research data management plans as a prerequisite to receiving funding.[144]

Overview

There is a growing demand for capturing and archiving a variety of digital outputs at higher education institutions, and the critical role of academic and research libraries is to work closely with researchers to address this challenge. Research data management is the field of library science that concerns the issues involved in creating raw research materials so they remain useful as much and for as long as possible, and it is a developing area in research-intensive universities.[145] The types of datasets that need to be managed during the research process are becoming increasingly complex and can include blog posts, email correspondence, algorithms, and even the content of applications. Libraries are beginning to play an important role in this collection process by providing one-on-one support to university departments, helping to develop and maintain data management infrastructure, and organizing data for further analysis and discovery.[146]

Librarians are not only learning how to preserve and manage a variety of new multi-format research outputs, but they are also making this content citable. This is especially true for large projects where funders or publishers are mandating that all related datasets be made publicly available.[147] Purdue University Library is supporting sustainable access to digital datasets through a research repository for university-affiliated projects. They assign digital object identifiers (DOI) to each dataset, which can be used by the researcher or others to cite the object properly.[148] Although not every university is able to develop their own online repository, there are other initiatives such as Zenodo, created by CERN and the pan-European initiative OpenAIREplus, for researchers' scientific output. Individuals, scientific communities, and libraries can upload multi-disciplinary research data into one location and share it widely.[149] This tool also ensures that software created on GitHub, for example, will be preserved and properly cited through a DOI.[150]

While solutions to the challenge of preserving multi-format datasets and finding ways to make them citable and discoverable in libraries is developing quickly, the rapid expansion of repository programs is creating a challenge in itself. The fragmented global research data landscape is becoming increasingly complex and is impeding the ability to share and discover data beyond an institution or discipline.[151] The vast amount of digital data in domain repositories has also led to sustainability issues. Funding for these repositories, especially in the US, has been deemed inadequate for the tasks required.[152]

Implications for Policy, Leadership, or Practice

Policies regarding the preservation, management, and dissemination of digital outputs of research affecting libraries are just beginning to take shape. The US Office of Science and Technology Policy has laid out policies to ensure that Federally-funded scientific research be made available to the public, industry, and scientific community.[153] The British Library, Cambridge University Library, Trinity College Library Dublin, and others are also following new regulations known as legal deposit to ensure that temporary materials such as websites and e-books can be collected, preserved, and made available to future generations of researchers for years to come.[154] At the university level, the OCLC Research Library Partnership Data Curation Policy Working Group has issued a call for action to address how libraries can support university-wide policies on research data management through assisting with copyright issues, providing guidance to help researchers meet deposit requirements, creating data management plans, and providing for preservation and access.[155]

In response to the constant evolution of policy requirements and data formats, library organizations are offering guidance to academic and research librarians through best practice publications and continuing professional development opportunities. The Council on Library and Information Resources' report, *Research Data Management Principles, Practices, and Prospects*, addresses the role that academic libraries can play in supporting the new US Federal data management requirements.[156] Similarly, the American Library Association's *Data Management for Libraries: A LITA Guide* offers a comprehensive primer on understanding, building, and maintaining a data management service.[157] Through the RDMRose project, the White Rose consortium of academic libraries at Leeds, Sheffield, and York work closely with the Sheffield Information School to produce research data management learning materials specifically for pre-service and in-service library professionals.[158]

Several solutions are already underway at academic and research libraries. The ScholarShip is a digital archive for the scholarly output of the East Carolina University community. Its mission is to capture, preserve, and share the intellectual output of East Carolina University's faculty, staff, and students.[159] At the University of Oxford, its Research Data website and working group was launched to support researchers in sharing, managing, and preserving their data and research materials.[160] Similarly, ScholarSphere at Penn State University is a secure repository service that enables the campus community to share its research and scholarly work with a worldwide audience. Faculty, staff, and students can use ScholarSphere to create a durable and citable record of journal pre-prints and post-prints, datasets, working papers, technical reports, conference papers, student work, audio and visual materials, annual reports, newsletters, and more.[161]

For Further Reading

The following resources are recommended for those who wish to learn more about capturing and archiving the digital outputs of research as collection material:

Memorandum for the Heads of Executive Departments and Agencies (PDF)
go.nmc.org/memor
(John P. Holdren, Executive Office of the President, 22 February 2013.) This memorandum lays out the Federal policy guidelines to support increased public access to the results of research funded by the US Federal Government. Digitally-formatted scientific data resulting from unclassified research supported by Federal funding should be stored and publicly accessible to search, retrieve, and analyze. > *Policy*

The National Archives Will Upload Everything to Wikimedia Commons
go.nmc.org/wikim
(Eric Hal Schwartz, *In The Capital*, 1 July 2014.) The U.S. National Archives and Record Administration is making it a high priority to upload all of its digitized data to Wikimedia Commons. > *Policy*

National Digital Stewardship Alliance
go.nmc.org/ndsa
(Library of Congress, accessed 9 July 2014.) The National Digital Stewardship Alliance (NDSA) is a consortium of organizations that are committed to the long-term preservation of digital information. > *Leadership*

Research Data Management in the Arts and Humanities
go.nmc.org/rdm
(Stuart Macdonald, University of Edinburgh Research Data Blog, 24 September 2013.) The tenth Research Data Management Forum, organized by DCC, was held in St Anne's College, University of Oxford to examine how humanities research data requires specific handling, along with identifying support, advocacy, training, and infrastructure needs. > *Leadership*

Sustaining Domain Repositories for Digital Data
go.nmc.org/repos
(ICPSR, 22 June 2014.) This statement describes the value, role, and uncertain future of data repositories as funding for domain repositories remains unpredictable and inadequate. > *Leadership*

Where are the Born-Digital Archives Test Data Sets?
go.nmc.org/bornd
(Butch Lazorchak and Trevor Stevens, *The Signal*, 26 March 2014.) This article describes the factors that make for effective digital preservation test datasets and how testbed data can be leveraged to explore digital preservation solutions. > *Practice*

Competition from Alternative Avenues of Discovery

Difficult Challenge: Those that we understand but for which solutions are elusive

Before the rise of the Internet, libraries were widely perceived as the ultimate gateways to knowledge.[162] They served as central locations for visitors to discover new information, compile research, and draw upon the expertise of librarians to direct them to the most helpful resources. In the past two decades, as the Internet has expanded, so has the array of educational content made easily accessible to people. This shift has not only impacted how people research, but also where they conduct research. Performing a simple web search on a topic, for example, often conjures pages of relevant articles, reports, and media. Furthermore, advancements in the semantic web are refining research results and enabling data to be shared across applications.[163] These advents in Internet technology are fostering changes in patron behavior, challenging libraries to either participate in the online knowledge exchange or risk becoming obsolete over time. As a result, libraries are tasked with rethinking how new information can be creatively delivered and discovered within their physical spaces

Overview

According to a faculty survey conducted by Ithaka S+R, the information gateway function of the library is declining.[164] The wealth of resources accessible through the Internet is making learning more ubiquitous, enabling people to seamlessly pursue their curiosities, expand their research, and disseminate their work. In the past decade, numerous online platforms have emerged that rival the offerings of libraries and print books, providing free educational content. Perhaps the best known service is Wikipedia, an encyclopedia-style site that contains nearly five million content articles and over 33 million pages, all created by millions of contributors across the world.[165] While many skeptics caution that Wikipedia is not a credible resource for academic research and writing projects due to the unreliability of the contributors,[166] the sheer number of registered users (21.5 million) indicates a shift in where people are going for information, for convenience and ease of use.[167]

Online environments such as Google Scholar and the Web of Knowledge curate data from multiple sources. Academic and research libraries are in the difficult position of having to compete with these channels, but have the opportunity to adapt and even partner with these platforms. The Center for Digital Education suggests transferring library resources to the cloud as a means of making them more accessible.[168] At Stockholm University Library, library staff no longer build collections or coordinate interlibrary loans, but are instead focused on ensuring that information is delivered quickly to researchers, students, and faculty through digital workflows. This strategy frees up more physical space in libraries where print materials used to be housed; library professionals can reconsider how the building itself is structured to accommodate deeper learning through hands-on technology training. In this vision, libraries are not only places of information discovery, but also places where people learn how to learn better.

An EDUCAUSE article explores the current landscape of information discovery and how libraries can adapt to play a larger role in it. In order to remain relevant, libraries must have multiple presences on the web to engage users wherever they prefer, including social media, widgets, mobile apps, and searchable databases like Ex Libris's discovery tool "Primo." While library resources appear in reading lists and catalogs are frequently showcased on university websites, leaders envision next-generation libraries where information discovery is a more social experience. EDUCAUSE suggests a library system that aggregates students' and researchers' reviews, ratings, and comments.[169] Consumer giants such as Amazon and Netflix have already demonstrated the power and popularity of smart recommendations, opening up doors for libraries to contemplate ways to tailor the content they deliver to individuals. Online social reading services such as GoodReads[170] and Shelfari[171] have been successful in making resource discovery a highly personal yet social process.

Implications for Policy, Leadership, or Practice

In order for libraries to be portals of discovery, they are continuing to find ways to expand their policies to work with emerging online services. OCLC Research launched the "Wikipedia Library Project" pilot in an effort to make sources for citations more accessible to Wikipedia editors.[172] Google Scholar has also partnered with libraries across the world to digitally house their content and support full text searches.[173] Dartmouth

College Library,[174] Leiden University,[175] and University of Manitoba Libraries[176] are among the many that have provided links to commercial scholarly content licensed for use at the institutions. However, in order for libraries to be effective partners in these initiatives, library professionals must be trained in and understand the nature of these digital resources. Funded by the Bill and Melinda Gates Foundation, the Digital Public Library of America's Public Library Partnerships Project aims to create and publicly share training policies and curricula that can be scaled for all sorts of library professional development.[177]

There is now an onus on library leaders to accurately understand how people prefer to learn and to incorporate those methods. The University of Rochester published the report, *Studying Students: the Undergraduate Research Project at the University of Rochester*, to examine how students work and provide conclusions how librarians can effectively and efficiently assist them. Shortly after, the university's libraries launched a mobile application that enables students to search their entire database and archives from wherever they have an Internet connection, along with an SMS system that texts students the call numbers of relevant books — both designed to make information discovery more seamless.[178] Since the release of the study, more than 40 universities have begun applying the research to improve their library facilities, but an assessment of the outcomes has not yet been published.

A recent Slate article explored libraries' potential transition from print materials to technology and training.[179] Academic and research libraries are incorporating more authentic experiences for information discovery — immersive opportunities that Google Scholar and Wikipedia cannot yet foster. Seattle University's Lemieux Library, for example, is home to the Media Production Center where students and faculty receive the training and support needed to turn their creative ideas into tangible products.[180] The University of Minnesota Library's Smart Learning Commons has a dedicated staff to assist students with learning new technologies.[181] Beyond supporting students on their course assignments, some libraries are offering opportunities for them to gain new skills that are relevant to the workforce. One such example is the Georgetown University Library, which provides workshops on social media marketing, data visualization, video editing, and other emerging areas.[182]

For Further Reading

The following resources are recommended for those who wish to learn more about competition from alternative avenues of discovery:

Open Discovery Initiative Survey Report
go.nmc.org/ODI
(NISO ODI Working Group, January 2013.) The Open Discovery Initiative aims to define standards and best practices for library discovery services that are based on indexed search. This report describes the results of 782 surveys completed by library members. > *Policy*

Envisioning the Library of the Future
go.nmc.org/envi
(Alan Davey, Arts Council England, May 2013.) The Arts Council England began research to understand how libraries can meet the needs of future patrons. This report outlines how libraries can respond to change in order to best serve their communities. > *Leadership*

As Researchers Turn to Google, Libraries Navigate the Messy World of Discovery Tools
go.nmc.org/discov
(Marc Parry, *The Chronicle of Higher Education*, 21 April 2014.) Libraries are beginning to offer one-step search boxes that comb entire collections rather than having users perform separate searches in each different specialized database. > *Practice*

Paths of Discovery: Comparing the Search Effectiveness of EBSCO Discovery Service, Summon, Google Scholar, and Conventional Library Resources
go.nmc.org/paths
(Association of College and Research Libraries, 2013.) This paper describes a study comparing the efficacy of Serial Solutions Summon, EBSCO Discovery Service, Google Scholar, and conventional library databases. > *Practice*

PressForward
go.nmc.org/pressf
(George Mason University, accessed 1 July 2014.) PressForward is a free WordPress plugin developed by the Roy Rosenzweig Center for History and New Media at George Mason University to capture and highlight orphaned scholarly work such as whitepapers and scholarly blogs. > *Practice*

The Student Experience and the Future of Libraries
go.nmc.org/experi
(JISC, accessed 1 July 2014.) The student experience will be critical to the future of libraries, which is why libraries must understand student behaviors more deeply. This article gives examples of how libraries are using ethnographic and data-driven insights to test and refine their services. > *Practice*

Embracing the Need for Radical Change

Wicked Challenge: Those that are complex to even define, much less address

Academic and research libraries are facing ongoing leadership issues that impact every aspect of their facilities and offerings, including updating staffing models and addressing a lack of financial resources. Compounding this challenge is the need to adapt to the rapidly evolving landscape of technology and to understand its impact on patron behaviors.[183] Once patron needs have been identified, libraries are tasked with revising or building new infrastructure to support more effective research practices, yet the change in focus on integrating innovations seems to be at odds with traditional modes of thought that govern academic and research libraries. Library leadership will require radically different thinking to provide adequate and sustainable support for new initiatives and business models. In order to be effective, this type of thinking will need to extend across the entire organization from the top down — from deans and directors to librarians, support staff, and new hires.

Overview

In a 2013 study conducted by the Bill and Melinda Gates Foundation for their Global Libraries Initiative,[184] nearly 80% of surveyed library stakeholders asserted that library professionals and leaders who embrace change are the most critical factors in the long-term success of their institutions.[185] Visionary and effective leadership, along with strong communication and advocacy, were also rated as key skills. Respondents considered concepts such as designing more appealing physical spaces to be secondary to the growth and open-mindedness of library staff, and even recommended funding partnerships that promote collaborations and the sharing of best practices between libraries. The challenge is in articulating what defines a visionary leader and how one can effectively foster change in a way that is well received by staff and patrons. Furthermore, the Association of Research Libraries reports major budget cuts across libraries since the 2008 recession, making it difficult to invest in organizational remodeling.[186]

According to a recent article from the *Huffington Post*, libraries are rapidly becoming technology hubs. This is evidenced through patrons locating resources through GPS-enabled apps, using 3D printers to create product prototypes, and borrowing tablets and e-readers for projects.[187] However, just as libraries implement programs that incorporate the latest technologies, new tools emerge that require them to switch gears and broaden their offerings. Published by the ACRL, *Restructuring Academic Libraries: Adjusting to Technological Change* outlines the issues that libraries must consider when navigating new technology frontiers. The book states that organizational development and restructuring are necessary to propagate networked information and computer-based services, but observes that these changes often occur at an incremental speed that is outpaced by advancements in technology.[188] A similar paper authored by the business and public administration reference librarian at the University of Idaho emphasizes the need for open systems thinking in which libraries attain a proper understanding of their own constraints.[189]

Ultimately, one of the barriers for faster transformation in the library sector is attitude. Satia Orange, former director of the American Library Association, once noted the importance of "prioritizing advancement, activism, service, and professionalism that will have an impact today for others who will stand on our shoulders tomorrow."[190] In this vision, library professionals work with local government administrators and community leaders to stay ahead of emerging trends and develop partnerships that enrich the experience of patrons. What makes this challenge a wicked one, however, is the lack of common language and protocols between libraries for instilling this attitude in library professionals at scale and translating it into realistic action items.

Implications for Policy, Leadership, or Practice

While individual libraries and programs are finding successful ways to embrace and instigate transformation, there is still a lack of policies that guide libraries through the sea changes. In Africa, several countries including Nigeria, Ghana, Ethiopia, and Malawi established national policies in an effort to develop plans and standards around the integration of information technology in academic libraries. Through studies, government organizations assessed the current state of ICT literacy and use in these countries, but in the resulting implementation programs, they have focused more on information technology as it relates to software,

rather than scholarly needs.[191] The vice president for information services and university librarian at Colombia University asserted that governments and institutions that fund academic libraries need to better understand the impact of current organizational models on student and faculty objectives. There is a need to measure user satisfaction, cost-effectiveness, and productivity while making sure library objectives serve institution, state, and national interest.[192] Pinpointing benchmarks and assessments for these criteria can lead to stronger policies that help library leaders update their infrastructure and better tailor their services to patrons. Additionally, policies are needed to address knowledge gaps in professional change management for libraries.

In order to foster the kind of attitude shift needed to drive real transformation, some library leaders are developing long-term strategies based on individual growth and rewards for staff. For example the Woodward Library at the University of British Colombia is in the midst of integrating their circulation and reference services into a single space and streamlining the technology and costs involved, with the goal of stimulating more efficient research for students.[193] In order to prepare for this change harmoniously, the circulation team drafted the *Strategic Plan*, which promotes continuous support and creative inspiration for staff — a potential model for other academic and research libraries. The library has committed to providing frequent new learning opportunities and training and to engaging the entire staff in planning for major organizational changes. Whenever the library infrastructure undergoes a transformation, the team will determine new roles and responsibilities together.[194]

This sort of visionary leadership from Woodward Library and other forward-thinking organizations has already proven to enhance library practices. The USC Libraries at University of Southern California launched the report series, *The Essential Library*, in which the entire library staff convened to determine their core values and mission in the midst of the evolving technology landscape and student/faculty needs.[195] After publishing their initial report, they made improvements to their services based on the three key themes they identified as imperatives: discoverability of library resources, integration with their community, and the physical and intellectual environment of libraries. As a result, the libraries made their collections more accessible, updating 46,000 scholarly records to improve the accuracy and usability of their catalogs, processed 47,000 linear feet of archival materials, and identified hundreds of new collections to share. Improvements also included a redesigned website with optimized searches that span information silos and all types of media to better assist students and faculty.

For Further Reading

The following resources are recommended for those who wish to learn more about embracing the need for radical change:

Collection Development Policy Statement
go.nmc.org/alab
(University of Alabama Library, accessed 25 July 2014.) The University of Alabama created a policy to guide decisions on how to collect knowledge with the essential principles being a system perspective, flexibility, and communication. > *Policy*

Creative Destruction in Libraries: Designing our Future
go.nmc.org/destruct
(Caro Pinto, *In the Library with the Leadpipe*, 20 November 2013.) This article considers what creative destruction can mean for libraries, and what libraries must give up to meet new challenges around budgets, space, personnel, and questions of relevance. > *Leadership*

Incremental and Radical Innovations in Research Libraries
go.nmc.org/radi
(Ronald C. Jantz, Rutgers University Community Repository, 2013.) This study seeks to define innovation in relation to how it affects the university research library, illuminating the major impediments to transformation. > *Leadership*

Library as a Verb: Technological Change and the Obsolescence of Place in Research
go.nmc.org/verb
(S.C. Baker, *Informing Science: the International Journal of an Emerging Transdiscipline*, 2014.) The author argues that libraries are a process rather than a place; evolving technologies have clarified the roles of libraries and librarians, proving that research is not relegated to a single building and that the librarian is more of an educator than a gatekeeper. > *Leadership*

Why the Academic Library Should Lead Higher Ed Change
go.nmc.org/whyac
(Joshua Kim, *Inside Higher Ed*, 12 March 2014.) Academic libraries could be in the best position to lead change in their higher education institutions because they already have experience with technology-driven change. > *Leadership*

Trends in Digital Scholarship Centers
go.nmc.org/cent
(Joan K. Lippincott et al., EDUCAUSE, 16 June 2014.) This article discusses the approaches of Brown University and McMaster University to illustrate how universities are creating their digital scholarship centers to support high-end digital projects. > *Practice*

Maintaining Ongoing Integration, Interoperability, and Collaborative Projects

Wicked Challenge: Those that are complex to even define, much less address

Research institutions have become more reliant on creating strong partnerships with other institutions to enhance their visibility and reinforce their standings in order to earn funding from agencies that are setting the bar higher and higher.[196] As a result, producing quality research and quantifying outputs has never been more important; however, the existing infrastructure for publication and dissemination often weighs down researchers with time-consuming administrative tasks. To make this process more efficient, interoperability has become a key issue for many academic and research libraries. Interoperability, in this context, is the ability to make research systems work together so that scientific knowledge and data can be exchanged seamlessly across institutions, sectors, and disciplines. The ultimate goal is to make it easier for institutions to share their findings with funding agencies and other stakeholders.[197]

Overview

Managing the dissemination and storage of research in digital repositories is a constant concern for libraries. There are many layers of identification and validation in the research ecosystem, and the myriad processes that enable its dissemination are hidden from view. Research information management is a relatively new profession, and it is one that is focused on developing standards for metadata and entire systems that can be integrated with others. Today's researchers are navigating a complex landscape in this regard; systems can be local, governmental, or even shared, and each have their own reporting systems that are built upon various APIs, schema, and semantics.[198] It is often the case that researchers must fill out a variety of forms when applying for funding to describe the same piece of research. Many in the field of research information management are working toward the recognition of a universal syntax to lower barriers to the exchange of scientific data and stimulate extensive collaboration across sectors and institutions.[199]

One difficulty researchers encounter is maintaining a single digital presence for their work, also known as an authority file or identity system. In the current landscape, researchers manage a number of profiles on services such as Mendeley, Microsoft Academic, Academia, and Google Scholar. Fragmented digital identities make it challenging for other researchers to view the full scope of someone's work and to ascertain whether their research or scholarly counsel should be considered for collaboration or further exploration. Academic and research libraries manage library name authority files that contain sufficient information to differentiate an author in their catalog; yet, these authority files are common to hundreds of other libraries, making it increasingly difficult to distinguish researchers among millions of others that are registered. The OCLC's Registering Researchers in Authority Files Task Group is an international body of specialists that are addressing the emerging need for persistent identifiers for researchers. Their goal is to create a system that can link and integrate all scholarly output of a given author and build a more dynamic model of authority.[200] ORCiD has also been successful in connecting researchers with their research by providing persistent digital identifiers throughout the process, including manuscript and grant submissions.

Increasing integration, interoperability, and collaboration between research institutions necessitates the participation of all stakeholders involved. A number of consortia have been formed to guide the development of procedures for research information management. Founded in 1990 by the Association for Research Libraries and EDUCAUSE, the Coalition for Networked Information (CNI) is dedicated to promoting the use of digital information to advance scholarship and education.[201] Because of digital scholarship's rapid evolution, CNI updates its program plan every year, and achieving interoperability of technology, standards, and infrastructure is one of the three key themes this year. The organization acknowledges that the challenge lies in coordinating the effort to realize this goal; that is, no one institution succeeds on its own. Confronting this task will require the inputs of an entire community of research institutions, all working with the unified mission of creating a standardized system that allows for the easy exchange of data and research between repositories.[202]

Implications for Policy, Leadership, or Practice

For academic and research libraries, the underlying challenge is in deciding on what type of strategy to

follow or join among the many that have been proposed by national alliances and global groups. Openness and the open access movement have advanced an entire category of initiatives that are being driven by the common principles of openness, sustainability, interoperability, and diversity. In March 2014, The Confederation of Open Access Repositories coordinated several major open access repositories to come together and work on a plan to align their activities regarding technical interoperability, policies, and services. The aim is to build the infrastructure to form a global repository network that allows researchers from every corner of the world to aggregate, analyze, and mine data and scientific knowledge freely.[203]

Many institutions have addressed increasing integration of services and interoperability on their own by developing their own frameworks for innovations in digital scholarship. OSU Libraries (OSUL) have created the Digital Initiatives Program Guiding Principles, which outlines a vision for digital architecture that is focused on the themes of innovation, iteration, collaboration, and user-driven design. Among the 11 guiding principles is the notion of offering services over products, moving from the model of individualized, siloed projects toward an approach that promotes long-term sustainability, integration, preservation, and accessibility. Furthermore, OSUL's guiding principles acknowledge their effort as an institution to participate in issues related to semantic data and repositories on a national and international level, with aspirations of building strategic partnerships with other universities and the greater library community.[204]

In Sweden, university libraries have constructed a cooperative model to align their institutional repositories with the Electronic Publishing Centre at the Uppsala University Library as the technical and organizational hub. According to project leaders, this jointly-funded system has allowed for smaller institutions with limited resources to enjoy the functionalities of larger universities that are part of the network. All participating institutions share DiVA as the common integrated framework which has streamlined their handling of metadata and persistent identifiers for authors, departments, subjects, and publication types. The idea is to synch up the description formats and agree on registration procedures as to what material is included in the database with the overarching goal of guiding the evolution of the system to meet the users' needs.[205]

For Further Reading

The following resources are recommended for those who wish to learn more about maintaining ongoing integration, interoperability, and collaborative projects:

The Research Data Alliance
go.nmc.org/rda
(Research Data Alliance, accessed 23 July 2014.) The Research Data Alliance is a global effort, sponsored by the NSF, European Commission, and Australian government to facilitate the interoperable sharing and exchange of data. > *Policy*

International Image Interoperability Framework
go.nmc.org/iiif
(International Image Interoperability Framework, accessed 22 July 2014.) A growing community of the world's leading research libraries and image repositories are producing an interoperable technology and community model for image delivery called the International Image Interoperability Framework.
> *Leadership*

JISC Digital Media Metadata Standards and Interoperability
go.nmc.org/intero
(JISC, accessed 23 July 2014.) This document describes the choices developers of multimedia collections have in terms of metadata standards and the principles behind using them. > *Leadership*

Digital NZ
go.nmc.org/diginz
(Digital NZ, accessed 23 July 2014.) Digital NZ pulls material from libraries, museums, government departments, publicly-funded organizations, the private sector, and community groups to allow users to search across more than 28 million digital items. > *Practice*

Structured Data by Default: Publishing Schema.org Metadata from Library Systems
go.nmc.org/sche
(Dan Scott, *Coffee Code*, 2 April 2014.) Open-source library systems such as Evergreen, Kaha, and Vufind allow researchers to publish highly structured data about library resources, library holdings, and even libraries themselves using the schema.org vocabulary.
> *Practice*

Top Trends in Academic Libraries
go.nmc.org/acrl
(*College & Research Libraries News*, June 2014.) The ACRL Research Planning and Review Committee found that the unifying theme of deeper collaboration is trending in higher education libraries in areas including data, device-neutral digital services, and competency-based learning. > *Practice*

Important Developments in Technology for Academic and Research Libraries

Each of the six developments in technology detailed in this section were selected by the project's expert panel using the Horizon Project's Delphi-based process of iterative rounds of study, discussion, and voting. In the NMC Horizon Project, technology is defined in a broad sense as tools and resources that are used to improve teaching, learning, creative inquiry, research, and informational management. While many of the technologies considered were not developed solely for academic and research libraries, they have clear applications in the field.

The technologies, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories — near-term technologies that are expected to achieve widespread adoption in one year or less; mid-term technologies that will take two to three years; and far-term technologies, which are forecasted to enter the mainstream use in libraries within four to five years.

The initial list of topics considered by the expert panel was arranged into categories that were based on the primary origin and use of the technology. The potential applications of the technologies featured, specifically in the context of global academic and research libraries, were considered in a series of online discussions that can be viewed at library.wiki.nmc.org/Horizon+Topics.

The expert panel was provided with an extensive set of background materials when the project began that identified and documented a range of existing technologies used in both education and beyond. The panel was also encouraged to consider emerging technologies whose applications for academic and research libraries may still be distant. A key criterion for the inclusion of a new technology in this edition was its potential relevance to academic and research libraries worldwide.

In the first round of voting, the expert group reduced the master set, shown on the next page, to 12 technologies that were then researched in much greater depth by the NMC staff before the list was cut in half during the final round of voting. Technologies that do not make the interim results or the final report are often thoroughly discussed on the project wiki at library.wiki.nmc.org. Sometimes a candidate technology does not get voted in because the expert panel believes it is already in widespread use, or, in other cases, they believe the technology is more than five years away from widespread adoption. Some technologies, while intriguing, do not have enough credible project examples to substantiate them.

There are currently seven categories of technologies, tools, and strategies for their use that the NMC monitors continuously. These are not a closed set, but rather are intended to provide a way to illustrate and organize emerging technologies into pathways of development that are or may be relevant to academic and research libraries. The list of seven categories has proven fairly consistent, but new technologies are added within these categories in almost every research cycle; others are merged or updated. Collectively, the categories serve as lenses for thinking about innovation; each is defined below.

> **Consumer technologies** are tools created for recreational and professional purposes and were not designed, at least initially, for educational use — though they may serve well as learning aids and be quite adaptable for use in academic and research libraries. These technologies find their ways into libraries because people are using them at home or in other settings.

> **Digital strategies** are not so much technologies as they are ways of using devices and software to enrich teaching, learning, research, and information management. Effective digital strategies can be used in both formal and informal learning; what makes them interesting is that they transcend conventional ideas to create something that feels new, meaningful, and 21st century.

> **Enabling technologies** are those technologies that have the potential to transform what we expect of our devices and tools. The link to learning in this category is less easy to make, but this group of technologies is where substantive technological innovation begins to be visible. Enabling technologies expand the reach of our tools, make them more capable and useful, and often easier to use as well.

- **Internet technologies** include techniques and essential infrastructure that help to make the technologies underlying how we interact with the network more transparent, less obtrusive, and easier to use.
- **Learning technologies** include both tools and resources developed expressly for learning, as well as pathways of development that may include tools adapted from other purposes that are matched with strategies to make them useful for learning. These include technologies that are changing the landscape of learning, whether formal or informal, by making it more accessible and personalized.
- **Social media technologies** could have been subsumed under the consumer technology category, but they have become so ever-present and so widely used in every part of society that they have been elevated to their own category. As well established as social media is, it continues to evolve at a rapid pace, with new ideas, tools, and developments coming online constantly.
- **Visualization technologies** run the gamut from simple infographics to complex forms of visual data analysis. What they have in common is that they tap the brain's inherent ability to rapidly process visual information, identify patterns, and sense order in complex situations. These technologies are a growing cluster of tools and processes for mining large data sets, exploring dynamic processes, and generally making the complex simple.

The following pages provide a discussion of the six technologies highlighted by the 2014 Horizon Project Library Expert Panel, who agree that they have the potential to foster real changes in academic and research libraries, particularly in the development of progressive services for research, information management, content delivery, and learning. As such, each section includes an overview of the technology; a discussion of its relevance to academic and research libraries; and curated project examples and recommendations for further reading.

Consumer Technologies
- 3D Video
- Electronic Publishing
- Mobile Apps
- Quantified Self
- Tablet Computing
- Telepresence
- Wearable Technology

Digital Strategies
- Bring Your Own Device (BYOD)
- Flipped Classroom
- Games and Gamification
- Location Intelligence
- Makerspaces
- Preservation/Conservation Technologies

Internet Technologies
- Bibliometrics and Citation Technologies
- Cloud Computing
- The Internet of Things
- Real-Time Translation
- Semantic Web and Linked Data
- Single Sign-On
- Syndication Tools

Learning Technologies
- Badges/Microcredit
- Learning Analytics
- Massive Open Online Courses
- Mobile Learning
- Online Learning
- Open Content
- Open Licensing
- Virtual and Remote Laboratories

Social Media Technologies
- Collaborative Environments
- Collective Intelligence
- Crowdfunding
- Crowdsourcing
- Digital Identity
- Social Networks
- Tacit Intelligence

Visualization Technologies
- 3D Printing/Rapid Prototyping
- Augmented Reality
- Information Visualization
- Visual Data Analysis
- Volumetric and Holographic Displays

Enabling Technologies
- Affective Computing
- Cellular Networks
- Electrovibration
- Flexible Displays
- Geolocation
- Location-Based Services
- Machine Learning
- Mobile Broadband
- Natural User Interfaces
- Near Field Communication
- Next-Generation Batteries
- Open Hardware
- Speech-to-Speech Translation
- Statistical Machine Translation
- Virtual Assistants
- Wireless Power

Electronic Publishing

Time-to-Adoption Horizon: One Year or Less

Already firmly established in the consumer sector, electronic publishing is redefining the boundaries between print and digital, still image and video, passive and interactive. Modern digital workflows support almost any form in which content might appear, from traditional print to digital, web, video, and even interactive content. Building in the full spectrum of potential publishing avenues — print, web, video, mobiles and tablets, and interactives — from the beginning is not only a way to streamline production overall, but also to increase the reach of the materials produced by leveraging the content over a wide range of media. Commonly categorized by libraries as new forms of scholarly communication,[206] electronic publishing is enabling libraries to produce content, either formally through a press or informally through a repository. If the first revolution in electronic publishing was making publishing platforms accessible to anyone, the next phase is the linking of these platforms together to produce new combinations and new types of content. New concepts such as responsive design and open access will allow that content to be archived as well as ported to any device, making it easier for libraries to publish resources that assist and reach people outside of the physical buildings.

Overview

Electronic publishing is creating a sea change in how people consume media, research, news, and narratives. Major media companies such as *The New York Times* and *Newsweek* are setting the standard for what electronic publishing can accomplish. Rich in digital media assets such as video, images, and audio, these digital building blocks can be easily deployed in a variety of media formats — a notion that has huge implications for expanding the reach of a library's content and the dissemination of academic research. Libraries are poised to be major players in the digital revolution as academic electronic publishing becomes more sophisticated. While the standard PDF format has long been supported in libraries, closed systems, such as Apple's iBook and Amazon e-books, are posing challenges to their existing publishing workflows. EPUB 3, a new standard for interactive and media-enhanced e-books, offers many opportunities for electronic publishing and new library content services,[207] but there are still no user-friendly tools available for library professionals to aid the process.

The emergence of open access policies from government agencies, coupled with unsustainable costs of print and citation cycles, has led to a shift in how education institutions publish.[208] Because of their inherent role of housing and maintaining university content, academic and research libraries are well-positioned to drive new scholarly communication initiatives across campuses. There is now motivation for libraries to take resources that are generated locally, including university research outputs, learning objects, and material digitized by faculty, and turn them into teaching materials as new publications. Among the chief considerations for libraries establishing such e-publishing workflows are storage capacity, comprehensive concepts for linking the scientific working process of text and scientific data, software tools that integrate and visualize complex data, copyright issues, bibliometric tools, and content hosting coordination.

When developing e-publishing strategies, there is also a need for libraries to consider the various ways in which the content will be consumed by students and faculty. DazeInfo predicts that mobile devices will be responsible for half of all video consumption by 2016[209] and according to Nielsen, the average American consumer spends 60 hours per week accessing content across their digital devices.[210] Advents in publishing technology, such as responsive design, could enable libraries to design and produce a publication irrespective of the format in which it may ultimately appear, and thus foster the flexibility to easily port content into many different formats, providing people with a variety of reading options.[211] With each format comes a unique experience that is constantly progressing to include more enhanced features at every turn. Electronic publishing reflects the convergence of several different forms of digital media into a single stream of production — a notion that is now being widely experimented with across the library sector.

Relevance for Academic and Research Libraries

As a growing amount of educational content becomes readily available via the Internet, libraries have a major incentive to more seamlessly connect people with their

resources and scholarly information. Well-established initiatives include the publishing of a range of scholarly content, such as conference proceedings, monographs, and theses and dissertations, as exemplified by universities such as Virginia Tech.[212] In this vein, libraries have adapted to publishing content, rather than simply purchasing content to share with their constituents. Academic and research libraries are currently focused on growing their activity around the creation of original publications through e-journals or e-books, research data, and learning content that supports institutional pedagogy. The University Library System at the University of Pittsburgh, for example, now publishes more than 35 scholarly online journals, developed through an online workflow that enables content to be consumed by students, faculty, and researchers across a variety of devices. [213]

New forms of open access publishing by libraries are making resources available to all. Using the Freemium Model of OpenEdition, libraries in France are creating and disseminating humanities and social science research publications and providing library professionals with training to work with the platform.[214] Through this type of publishing, libraries will be able to take a more active role in supporting and guiding compliance for sharing and measuring institutional research outputs. In the midst of this rapid transition, however, there is a need for libraries to assess their publishing programs and envision methods for future-proofing them. The Purdue University Libraries and University Press released the report, *Library Publishing Services: Strategies for Success*, which analyzed the extent to which publishing has become a central focus of North American academic libraries. Only 15% of surveyed libraries developed a strategy for sustaining their publishing services long-term, and 20% have yet to evaluate the effectiveness or outcomes of their current model. Included in the recommendations were the need for libraries to deeply consider their audience segments and their needs for each publishing initiative and provide frequent training opportunities for staff.[215]

Library leaders and staff can look to library organizations, such as the Library Publishing Coalition, for directories of library-based publishing programs that are worthy of emulation.[216] CNI also published a report, based on an executive roundtable discussion, called *Institutional Strategies and Platforms for Scholarly Publishing*, which explores the current state of academic publishing services along with key considerations and concerns for libraries and university press. While libraries have been developing and contributing to open journal services for the past decade, many institutions' recent interest in moving away from the PDF format to XML is raising questions about standards, validation, and the entire editorial process. There is still a fundamental need for establishing effective business models for libraries to successfully increase the range and level of sophistication of their electronic publishing services.[217]

Electronic Publishing in Practice

The following links provide examples of electronic publishing in use that have direct implications for academic and research libraries:

ARL Scholarly Communication
go.nmc.org/arlscho
The ARL Scholarly Communication program encourages the advancement of effective models of scholarly communication that provide barrier-free access to quality information. > *Leadership*

ANU Press
go.nmc.org/anup
Australian National University established ANU Press in 2003 to explore and enable new modes of scholarly publishing. ANU Press provides open access to its electronic production of scholarly works. > *Practice*

Vectors
go.nmc.org/vect
Vectors is a University of Southern California scholarly journal that focuses on how technology shapes, transforms, reconfigures, and/or impedes social relations. It uses a peer-reviewed format to publish only works that need to exist in multimedia. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about electronic publishing:

Building on Digital Libraries' Growing Momentum
go.nmc.org/mome
(Gracian Chimwaza et al., *University World News*, 20 June 2014.) Digital libraries with offline and online resources in the scientific, technical, and medical disciplines, such as The Essential Electronic Agricultural Library, Research4Life programs, and eGranary, are vital in bringing learning resources to low income and rural areas of the world. > *Leadership*

College Libraries Push Back as Publishers Raise Some E-Book Prices
go.nmc.org/pushb
(Avi Wolfman-Arent, *The Chronicle of Higher Education*, 16 June 2014) This article describes how academic libraries have long been dealing with the costs and difficulties of being locked into contracts with commercial publishers in order to gain access to electronic journals. > *Practice*

Mobile Apps

Time-to-Adoption Horizon: One Year or Less

For several years now, a revolution has been taking place in software development that parallels similar shifts in the music, publishing, and retail industries. Mass market is giving way to niche market, and with it, the era of highly priced large suites of integrated software has shifted to a new view of what software should be. Mobile operating systems such as Android and iOS have redefined mobile computing, and in the past five years, the small, low-cost software extensions to these devices — apps — have become a hotbed of development. Simple but useful apps have found their way into almost every form of human endeavor, and a popular app can see millions of downloads in a very short time. Online app marketplaces provide an easy and highly efficient way to deliver software that reduces distribution and marketing costs significantly. Early adopters of mobile apps in academic and research libraries include North Carolina State University Library, University of Minnesota Library, and University of Pennsylvania Libraries.[218] Mobile apps continue to gain traction in academic and research libraries, because they are particularly useful for learning as they enable people to experience new concepts wherever they are, often across multiple devices.

Overview

With the advent of mobile apps, the way we think about software itself is changing, and whole industries are adjusting to a new world in which sophisticated but simple tools routinely sell for 99 cents or are completely free. In contrast with the model for desktop applications that stack feature upon feature in a one-size-fits-all approach, mobile apps are small, simple, and elegant. They generally do one thing, or a small list of tightly related things, extraordinarily well. They cost so little, trial versions are unnecessary, and it is simple to outfit a tablet or mobile phone with exactly the feature set one wants for far less than one would pay for typical desktop software. Both Apple[219] and Google[220] have developed extensive collections of apps, and adding to one's set is as simple as it is inexpensive. The Library Success Wiki Site highlights the growth of this consumer technology in academic and research libraries through a list of up-to-date mobile apps from universities around the world.[221]

The app software model is clearly working: 75 billion apps had been downloaded in the Apple marketplace and over 80 billion in the Android marketplace by June 2014.[222] Those numbers just scratch the surface of the anticipated growth of mobile apps. A recent study by Gartner predicted that 268 billions apps will have been downloaded by 2017 — or, around 38 apps per person across the entire population of the earth.[223] The assortment of available apps is wide-ranging, from those that extend the camera or sensors on the device ("VSCO Cam,"[224] "Snapseed,"[225] and "Vine"[226]); to new forms of newspapers and magazines ("National Geographic"[227]) to games that make use of gestures in clever ways ("Candy Crush Saga"[228]); to crowdsourced mapping tools ("Waze"[229]); to apps that make restaurant recommendations based on the user's location ("Urbanspoon"[230]).

What makes apps as a category interesting to academic and research libraries are two key factors: the first is that there are so many to choose from — one can find an app to support almost any interest or endeavor, and the possibilities expand every day. The second is that they are inexpensive — rare is an app on someone's mobile that costs more than $1.99. Taken together, the result is that it is both easy and economical to completely customize a device to suit one's own interests. The best apps are tightly integrated with the capabilities of the device itself, using location data, motion detection, gestures, access to social networks, and web search, to seamlessly create a full-featured experience. As just one example, users are now able to not only read an article foregrounded because of its relation to the user's location, but also to share it with their social networks, make comments, swipe over an image to see more, and store specific content to read at a later date — all within a typical academic journal app.[231]

Relevance for Academic and Research Libraries

Mobile apps embody the convergence of several technologies that lend themselves to use in academic and research libraries, including annotation tools, applications for creation and composition, and social networks. Built-in GPS is being used to leverage the power of location and positioning in completely new ways, such as a recently funded project at the University

of North Carolina at Charlotte. Using proximity marketing technology, the project will use a location-based mobile application to push news and research notifications to registered university students.[232]

The potential of mobile computing is already being demonstrated in a wide variety of projects at academic and research libraries.[233] Boopsie, a mobile app developer, has created custom-branded native mobile apps for over 2,500 libraries, including the Mendik Library at New York Law School.[234] Using "Mendik Mobile," patrons can search catalogs, find books professors have placed on course reserve, log in to renew books and pay fines, and use external search engines for free research resources.[235] Libraries often curate collections of popular external apps on their mobile app platforms. MIT Libraries' website includes links to popular apps that make conducting library research easier for students and researchers on the go. For example, "PubGet"[236] delivers full text journal articles to tablets, "EBSCOhost"[237] enables extended article searching and reading, and "WolframAlpha"[238] provides more access to scientific data not found easily through Google and traditional search engines. Librarians too are using mobile apps to complete tasks and perform their jobs more efficiently.[239]

As academic and research libraries begin to understand the potential of external apps, they are going beyond providing searching and reading tools by developing their own apps to create greater awareness of how libraries can assist students and faculty. Grand Valley State University Library's mobile app "Library Quest"[240] leverages gamification to orient students to library collections and services. In this task-based game, students engage with the library space and earn points and rewards along the way. In one activity, titled "Home Sweet Homepage," students locate and enter the library's Twitter handle into the app to earn points for chances to win valuable prizes and earn library perks.[241] Similarly, East Carolina University's Joyner Library was recently awarded a grant to develop the "Research Roadmap" mobile app to guide university researchers on the research process from conception to completion using university-specific and discipline-specific library resources.[242]

Mobile Apps in Practice

The following links provide examples of mobile apps in use that have direct implications for academic and research libraries:

Bavarian State Library
go.nmc.org/bava
The Bavarian State Library in Germany offers multiple mobile apps that allow users to explore ancient texts with augmented reality, location-based features, and geo-referencing in historical maps. > *Practice*

Curtin University Library App
go.nmc.org/curt
The Curtin University Library app provides quick access to library resources and facilities from an iPhone, iPad, or iPod Touch. Users can access personalized subject guides, an animated books display, real-time computer availability, and barcode scanning of library items. > *Practice*

TU/e Library
go.nmc.org/tue
The Information Expertise Center at Technische Universiteit Eindhoven in the Netherlands created the "TU/e Library" app to enable library users to perform common transactions from their iOS mobile device, such as searching the catalogue, viewing title metadata and full text, storing favorites, viewing loan history, and seeing the status of desired titles. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about mobile apps:

Reading in the Mobile Era
go.nmc.org/reading
(UNESCO, 2014.) Through apps, mobile phones offer a new, affordable way to access reading material, and UNESCO is studying the demographics of this trend so that mobile technologies can be better leveraged to facilitate reading. > *Leadership*

Library Quest: Developing a Mobile Game App for A Library
go.nmc.org/libquest
(Kyle Felker, *ACRL TechConnect Blog*, 17 September 2013.) This essay explains how creating a gamified library app turned into a challenging endeavor so that other libraries can learn from the experience. > *Practice*

Student-Designed Apps Address Real University Research Needs
go.nmc.org/IMLS
(David Ward, *IMLS Blog*, 19 June 2013.) The Undergraduate Library at the University of Illinois is using an IMLS grant to allow students the opportunity to design library apps as part of the Minerva Project. > *Practice*

Bibliometrics and Citation Technologies

Time-to-Adoption Horizon: Two to Three Years

Coined in 1969 by Alan Pritchard, bibliometrics is the set of mathematical and statistical methods to quantitatively analyze citations and content of academic literature.[243] The technology has advanced rapidly in the age of computers as new algorithms are being developed to better gauge an author or journal's impact in the field, and help researchers efficiently filter through research databases or select the most appropriate journal for publication. Bibliometrics encompasses citation count, journal impact factor (JIF), and h-index, among other metrics that can be used to support grant applications, attainment of new and tenured positions, and requests for raises or promotions. The demand for citation technologies has given rise to a crop of sophisticated filtering tools that are replacing old metrics with methods based on measurements of semantic publishing. These metrics take into account sharing and annotations via the web and exchanges of data to evaluate the impact of a scholarly work. Advances in bibliometrics are helping academic and research libraries maintain a competitive edge by maximizing the influence of their scientific outputs, and thus reinforcing their effort to gain funding.

Overview

Thomas Reuters's Journal Citation Reports (JCR) have been a key player in bibliometric technologies since the 1980s due to their method of systemic, objective evaluation of scientific journals. This system is based on the journal impact factor (JIF), which is determined by the number of times an article in the journal is cited over one year. This bibliometric measure provides a starting point for researchers who are seeking to publish in journals that are frequently cited in their fields, thus increasing their potential to garner citations.[244] Other metrics offered by JCR include the Eigenfactor Metrics, which operates under information and network theories, taking into account the whole structure of the citation network of an article when determining citation influence in scholarly literature. This type of innovation in bibliometrics gives researchers a clearer view of where their work fits into the larger scheme of scientific pursuits, with the goal of integrating their knowledge into other fields.[245]

A popular tool for citation analysis is Web of Science, also from Thomas Reuters, a citation index that offers multidisciplinary coverage of over 12,000 journals worldwide, including open access journals, along with a suite of bibliometric tools to track an article's impact and influence. The articles in the Web of Science are linked by their references, creating a network of scientific discoveries that are interrelated and thoroughly tracked.[246] Another widely used database among academic and research libraries is Elsevier's Scopus, which contains a vast array of peer-reviewed articles.[247] Scopus offers a similar suite of analysis and visualization tools that enable researchers to identify subject experts, track citations over time, and view an author's h-index,[248] among others.[249] The company recently acquired Mendeley, a start-up for sharing research online that houses over 60 million papers from more than one million users.[250] Leaders from Elsevier have expressed their desire to keep Mendeley social, open, and collaborative, while refining their platform and citation technologies.[251]

A notable innovation has been the debut of altmetrics, an open bibliometrics technology that is based on the social web for information scholarship and analyis.[252] The creators of altmetrics sought to improve filters to help scientists and scholars more efficiently sort through relevant publications. They target the peer review process, citation counting, and JIF as methods that do not adequately convey an article's impact, especially beyond the academy. Altmetrics takes into account a scholar's online social media imprint as well as their ability to publish their own research in repositories and disseminate it through blogging or other avenues. The idea is to consider the conversations as an accurate method of tracing impact in an ecosystem that is already web-based and social in nature over time. Using public APIs, altmetrics seek out timestamps, usernames, and tags to reflect impact.[253] While empirical research to determine if altmetrics accurately measures impact over buzz is ongoing, many academic and research libraries are taking note of innovative approaches as another means of quantifying their institution's scholarly impact.

Relevance for Academic and Research Libraries

Bibliometrics is crucial to quantitatively demonstrating the quality of an institution's research, and these measures

are considered by major funding organizations. The UK's Research Excellence Framework (REF), for example, has recently updated their method of assessing submissions to new criteria that takes into account an institution's impact to determine their quality of research.[254] For every submission received, REF's agencies will create a quality profile that includes overall quality, impact, and environment that will be the basis of the organization's decision making as they allocate funds. Academic and research libraries are increasingly expected to guide researchers' decisions as they choose methods of publishing that will optimize their significance and reach, and thus make them better candidates for grants.

The response to innovations in bibliometrics and citation technologies can be seen in the formation of international organizations that are dedicated to further exploration and training in the quantitative analysis of research. Founded in 2010, The European Summer School for Scientometrics (esss) is a collaboration between the University of Vienna, the Humboldt University of Berlin, the Institute for Research Information and Quality Assurance, and the Katholieke Universiteit Leuven to address the increasing demand for research quality managers and lack of adequate training for scientometrics, the study of measuring science, technology, and innovation.[255] At the 2013 esss annual meeting, esss trainers presented a convincing argument in support of the development and integration of a specialized bibliometrics department into academic and research libraries. Their detailed rationale, models for organization embedding, and project examples conveyed a clear relationship between librarians and their potential to innovate in the field of bibliometrics and help researchers make a greater impact. [256]

Academic and research librarians are constantly challenged to stay ahead of the curve and educate their institution on progressive approaches to measuring scholarly impact, such as altmetrics. Leaders in the field recently published *Riding the Crest of the Altmetrics Wave*, a guide that helps library scientists as they discover how this new metric works. The authors recommend becoming familiar with existing literature and discussions surrounding altmetrics, which have identified important concepts such as "impact flavors," which librarians can use to help researchers optimize their journal selection, taking into account the type of altmetric sources such as Mendeley versus Facebook bookmarks. They also advise librarians to experiment with reading altmetrics using ImpactStory.org as a starting point, an open-source web application where scholars can upload their products and then find out their altmetrics and citation count. As the ecosystem for citation technologies continues to diversify, librarians will need to educate students and faculty on how these innovations are relevant for understanding publishing choices and using specific databases.[257]

Bibliometrics and Citation Technologies in Practice

The following links provide examples of bibliometrics and citation technologies in use that have direct implications for academic and research libraries:

BiTeM Group
go.nmc.org/bitem
The University of Applied Sciences, Geneva established the BiTeM Group, which focuses on text mining and bibliometrics for clinical and biological data. > *Leadership*

ISNI
go.nmc.org/isni
The OCLC partnered with La Trobe University Library to beta test a service that accepts files of researcher name metadata for the purpose of assigning International Standard Name Identifiers to the university's researchers. > *Practice*

ORCID
go.nmc.org/orcid
ORCID provides a persistent digital identifier that distinguishes one researcher from another, and, through integration in key research workflows, supports automated linkages between a person and their professional activities ensuring that each person's work is recognized.
> *Practice*

For Further Reading

The following resources are recommended for those who wish to learn more about bibliometrics and citation technologies:

Towards a Common Model of Citation: Some Thoughts on Merging Altmetrics and Bibliometrics
go.nmc.org/citat
(Mike Taylor, *Research Trends*, December 2013.) This research aims to align the studies of altmetrics and bibliometrics by developing a common theoretical model that allows for analysis of all forms of accessible reference to scholarly objects. > *Leadership*

Development and Tuning of an Original Search Engine for Patent Libraries in Medicinal Chemistry
go.nmc.org/develop
(E. Pasche et al., *BMC Bioinformatics*, 2014.) The development of advanced text-mining applications dedicated to patents of the biomedical field are rare, though the biotech and pharmaceutical industries intensively use patent libraries. > *Practice*

Open Content

Time-to-Adoption Horizon: Two to Three Years

The movement toward open content reflects a growing shift in the way scholars in many parts of the world are conceptualizing education to a view that is more about the process of learning than the information conveyed. Information is everywhere; the challenge is to make effective use of it. Open content uses open licensing schemes to encourage not only the sharing of information, but the sharing of pedagogies and experiences as well. Part of the appeal of open content is that it is a response to both the rising costs of traditionally published resources and the lack of educational resources in some regions. As this open, customizable content — and insights about how to teach and learn with it — is increasingly made available for free over the Internet, people are learning not only the material, but also the skills related to finding, evaluating, interpreting, and repurposing the resources. Open content is growing in breadth and quality, as is the use of these materials in academic and research libraries.

Overview

Understanding that the term "open" is a multifaceted concept is essential to following this technology topic; often mistaken to simply mean "free of charge," advocates of openness have worked towards a common vision that defines it more broadly — not just free in economic terms, but also in terms of ownership and usage rights. Open content, or open education resources (OER), uses Creative Commons and other forms of alternative licensing. The goal is that embracing openness will lead to the unimpeded distribution of valuable, scientific knowledge and other educational resources that are freely copiable, freely remixable, and free of barriers to access, cultural sensitivities, sharing, and educational use.

Open content, as it is described here, has its roots in a number of seminal efforts, including the Open Content Project,[258] MIT's Open Courseware Initiative,[259] the Open Knowledge Foundation,[260] and work by the William and Flora Hewlett Foundation,[261] among others. Many of these projects focused on creating collections of sharable resources and on devising licenses and metadata schemata. This environment has produced an expansive network of education collaborators — researchers, faculty, and librarians who are creating, adapting, and sharing media — and numerous repositories brimming with content. Libraries are perfectly situated to lead open content initiatives because of their relationship to key institutional stakeholders that are involved with developing content, and their expertise in cataloging and metadata schemes, IT services, and their capacity for organizing workshops. [262]

As more institutions begin incorporating open content to increase their return on investment and lower costs for students, libraries are becoming more involved with the process.[263] Yet studies show that library services can be leveraged more in this regard; a recent study from Utah State University focused on the use of OER for language learning found that while open content is increasingly being used in university-level courses, nearly three-quarters of language program directors surveyed responded that they had not considered their institution's libraries as a resource to support the development and use of OER for instruction.[264] The role that academic and research libraries play in the integration of open content into higher education has been addressed directly by the Open Courseware Consortium, an organization with a membership of over 150 community and technical colleges in the United States.[265]

Relevance for Academic and Research Libraries

Increased use of OER in higher education has made academic libraries the coordinators of campus units in the development of open content. Institutions that are implementing large-scale open content initiatives are relying on their libraries to lead the charge; recently, OSU Libraries of Oregon State University embarked on a pilot program that manages OSU Press and OSU Extended Campus in the creation, review, and support of open textbooks.[266] To initiate the process, OSU Libraries disseminated an RFP seeking faculty members that were interested in creating interactive open textbooks for high-enrollment undergraduate courses including geosciences, marine biology, and agricultural sciences among others. The four selected titles will be published in 2014-2015, and will be available for students in four digital formats — PDF, HTML, iBooks, and ePub — as well as print on-demand.[267]

As more libraries become involved in the validation and organization of OER for their institutions, a number of projects are addressing the academic librarians' changing responsibilities throughout this process, namely the matter of copyright knowledge. Creative Commons affiliates in Colombia, El Salvador, and Uruguay worked with the Karisma Foundation on the development of an online course for the School of Open on P2PU that has modules covering international copyright restrictions, alternative licensing schemes, and applications of these standards. The course was adapted and translated from an online course for librarians by the Berkman Center for Internet & Society at Harvard University, which has also been translated into Romanian, Arabic, French, Russian, and Chinese.[268]

As universities start transitioning to open textbooks, academic and research libraries are tasked with supporting faculty directly in the curation, validation, and organization of OER for high-quality courses that are complete and legally sound. At Chadron State College in Nebraska, for instance, administrative decisions to save students money have led to university librarians becoming more deeply involved in the creation of courses — namely those that leverage copyright-free digital OER. With the goal of building entire programs based on free, credible resources from the web, librarians are working on interdisciplinary teams composed of subject matter experts, an instructional designer, an LMS specialist, and a student researcher; librarians' key roles are in the selection and documentation of relevant, credible open content that match the subject matter experts' criteria, and the research and resolving of any intellectual property issues.[269]

Open Content in Practice

The following links provide examples of open content in use that have direct implications for academic and research libraries:

Open Access Policy at Emory
go.nmc.org/emory
Emory University's open access policy is a rights-retention instrument ensuring that members of the university community may choose to post works of scholarship that are accessible to the world without charge. An open access repository provides the mechanism and infrastructure to assure permanency and free access to these works. > *Policy*

OpenGLAM
go.nmc.org/oglam
The mission of OpenGLAM is to help galleries, libraries, archives, and museums take steps to open up their collections and metadata so that anyone can use, reuse, and redistribute it. > *Leadership*

Staffordshire University Online Repository
go.nmc.org/staf
The Staffordshire University Online Repository is an open access institutional research repository designed to house the research and scholarly output of the University's staff and researchers. Content includes peer-reviewed journal articles, conference papers, book chapters, reports, exhibition catalogues, theses, artworks, and multimedia recording. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about open content:

The Benefits of Open Source for Libraries
go.nmc.org/benefits
(Ben Showers, JISC, 10 September 2013.) Through a question and answer format, this article first lays out benefits of open source and then addresses some issues libraries are facing, providing inspiration for library professionals to adapt their strategies. > *Leadership*

Why Open Access is the Next Frontier for Science
go.nmc.org/nextfront
(Tom Cochrane, ABC, 26 June 2014.) This article argues that young scientists need support in new ways of publishing and disseminating, more structured and responsible approaches to the management of the data, and more responsible management of academic and scientific software. > *Leadership*

Watch This Multi-Billion Dollar Industry Evaporate Overnight
go.nmc.org/evap
(Dylan Tweney, *VentureBeat*, 6 June 2014.) Academic journals are a multi-billion-dollar industry worldwide dominated by a handful of publishers, but new open publishers such as the Public Library of Science, Arxiv.org, and Academia.edu are creating a significant threat to traditional publishers by reaching more people at no cost. > *Practice*

The Internet of Things

Time-to-Adoption Horizon: Four to Five Years

The Internet of Things (IoT) is a network of connected objects that link the physical world with the world of information through the web. The advent of TCP/IPv6, launched in 2006, expanded the capabilities of the Internet and enabled objects, sensors, and devices to be addressable and thus findable across the Internet.[270] This augmented address space is particularly useful for tracking objects that monitor sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, identification, and similar applications. Embedded chips, sensors, or tiny processors attached to an object allow helpful information about the object, such as cost, age, temperature, color, pressure, or humidity to be transmitted over the Internet. This simple connection allows remote management, status monitoring, tracking, and alerts if the objects they are attached to are in danger of being damaged or spoiled. Many web tools allow objects to be annotated with descriptions, photographs, connections to other objects, and other contextual information; the Internet of Things makes access to these data as easy as it is to use the web.

Overview

The Internet of Things, a concept advanced by IP co-creator Vint Cerf, is the next step in the evolution of smart objects — interconnected items in which the line between the physical object and digital information about it is blurred. The advent of IPv6 has extended the Internet address space significantly, thus providing an avenue for any object, similar to today's webcams or shared printers that use the Internet, to transmit and receive data and information from an object or piece of equipment. On the consumer side, we already have Internet-enabled phones, thermostats, picture frames, and office equipment. Some pundits predict the next wave as Internet-enabled electric meters that use the Smart Grid to let your house know to raise the ambient temperature a degree to help offset a peak load.[271] Indeed, Internet pioneer Vint Cerf sees the Smart Grid as an accelerator for the Internet of Things.

While there are many examples of what the Internet of Things might look like as it unfolds, it is still today more concept than reality, although that is changing rapidly. At the same time, the underlying technologies that will make it possible, such as smart sensors that can easily be attached to everyday objects to monitor their environment or status, are all well understood, easily mass-produced, and inexpensive. These sensors are built to detect the elements and conditions around us, including sound, motion, pressure, temperature, light, and more. This is especially helpful for libraries as they house books and tangible research products. In many current cases, the sensors communicate with mobile apps, alerting people, for example, if they have left a building without locking their front door through "Goji Smart Lock"[272] or if a storm has caused flooding when they are away.[273]

It is no longer far-fetched to envision a world where all objects and devices are connected to act in concert, regardless of brand or vendor. For example, the location-awareness inherent in a smartphone knows when a user has stepped foot into a grocery store and could automatically communicate with sensors inside the user's refrigerator to let them know what food has expired and needs to be replaced. When that person returns from the grocery store, simply opening the front door would cue the Nest Learning Thermostat to adjust the temperature to their pre-stated preference.[274] For libraries, this type of technology can be applied to inventory management, an activity that requires much manual work. Researchers at Xi'an University of Technology, Xi'an Technological University, and Xi'an Jiaotong University in China are designing an IoT solution that automates this process through intelligent bookshelf layouts and a layered application framework.[275]

Relevance for Academic and Research Libraries

While Internet-enabled appliances are gaining traction in the consumer industry, concrete and well-documented implementations for academic and research libraries are difficult to find, though potential applications are easy to imagine. A writer for *American Libraries Magazine* envisions a future library where the Internet of Things allows patrons to have more control over their experience there, including being able to customize the lighting scheme or color of a room. He points to Revolv, an app-based sensor that enables users to personalize physical spaces, along with Belkin's WeMo Maker device, which allows users to add Internet

connectivity to any object controlled with a DC switch, including research robotics and motors so they can be easily monitored.[276] Another article published by the ALA contemplates the potential of the Internet of Things to power "smart shelves" in libraries that are responsive to patron's preferences, previous Internet searches, and circulation history in order to promote relevant content to them in real-time.[277]

This incarnation of the Internet of Things is already being leveraged in similar settings, such as museums, where staff monitor the conditions of paintings and ancient artifacts in real-time through sensors. These devices can alert humans to long-term problems associated with changes in condition, or better yet, trigger other systems to initiate change that will ameliorate or reverse environmental conditions that are detrimental to the care and preservation of collections and individuals. At the Metropolitan Museum of Art, for example, a partnership with IBM has enabled the installation of interlinked sensors to track the temperature and humidity, along with the artworks' response to climatic conditions.[278]

Advancements in the Internet of Things could also connect people's interactions with library catalogs online with their experiences in the physical facilities. Many catalogs currently offer a "favorite" so users can easily add items to their virtual list of preferences and readings. Through an IoT-enabled app, maps and directions to each of those resources can be provided to patrons upon entering the library.[279] Emerging applications of this technology are also pushing the boundaries and depth of information that can be made accessible to the public. Archaeologists from the University of Bristol, for example, are embedding sensors in historical objects from the transatlantic slave trade for "Reflector," a project that aims to share stories through authentic pieces of history that would otherwise not be available to the masses.[280] Every artifact has a story and presents an opportunity for learning about history and culture, and the Internet of Things is making it easier — and more automatic — to communicate them.

The Internet of Things in Practice

The following links provide examples of the Internet of Things in use that have direct implications for academic and research libraries:

Internet of Things Academy
go.nmc.org/iota
The Internet of Things Academy is part of Sony's Futurescapes project that explores the development of an open, educational Internet of Things platform to encourage creativity, collaboration, and technological literacy. > *Leadership*

OCLC Symposium on The Internet of Things
go.nmc.org/iotsymp
OCLC recently hosted an event to discuss predictions for the Internet of Things and the impact of entire systems of objects becoming connected. Libraries could potentially use a dashboard to view key indicators like how library visitors are interacting with library assets. > *Leadership*

IEEE Internet of Things Journal
go.nmc.org/iotj
IEEE is launching an IoT Journal for which it recently issued a call for proposals. Topics will include IoT system architecture, enabling technologies, services and applications, and the social implications. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the Internet of Things:

Adding Semantics to Internet of Things
go.nmc.org/semantics
(Xiang Su et al., Wiley Online Library, 14 January 2014.) This paper examines enabling technologies for adding semantics to the IoT. The experiment illustrates encoding and decoding of different data formats and shows how great a difference a data format can make in energy consumption. > *Leadership*

Context Aware Computing for The Internet of Things: A Survey
go.nmc.org/context
(Cornell University Library, 5 May 2013.) Understanding sensor data is one of the main challenges that the IoT will face. This paper analyzes and evaluates context-aware computing research efforts to understand how challenges in the context-awareness field have been tackled in desktop, web, mobile, sensor networks, and pervasive computing paradigms. > *Leadership*

The Internet of Things in the Library
go.nmc.org/inthelib
(Sarah Roullard, *libserra Blog*, 1 November 2013.) The author speculates how the Internet of Things technologies could be applied to library tasks such as collection and inventory management and streamlined patron check-outs. > *Practice*

Semantic Web and Linked Data

Time-to-Adoption Horizon: Four to Five Years

Semantic-aware applications infer the meaning, or semantics, of information on the Internet using metadata to make connections and provide answers that would otherwise be elusive or altogether invisible. In the library world, a similar sharing of metadata has been accomplished for nearly 50 years using the machine-readable cataloging format. However, there is a trend toward connecting the metatdata found in library catalog systems with the Internet through variations on linked data.[281] Semantic searching is being applied to scientific inquiries, allowing researchers to find relevant information without having to deal with apparently similar, but irrelevant, information. Semantic applications and linked data have the potential to be immensely powerful educational resources that enable students and researchers to more effectively sift, query, and gather relevant information.

Overview

Sir Tim Berners-Lee, director of the World Wide Web Consortium, originally advanced the vision for the semantic web.[282] His idea is that eventually the semantic web might be able to help people solve very difficult problems by presenting connections between seemingly unrelated concepts, individuals, events, or things — connections that it would take many people many years to perceive, but that could become obvious through the kinds of associations made possible when the semantics of the data are exposed.[283] In essence, the semantic web makes human-readable information understandable and reusable by computers through metadata about webpages and how they relate to each other. Linked data embodies the semantic web by structuring machine-readable information so that computers can make connections between relevant collections of data, such as library catalog metadata.[284]

Semantic-aware applications and linked data are intended to assist with searching and discovery, making intellectual or social connections, and advertising. Currently, semantic searching is used primarily to streamline scientific inquiries, allowing researchers to find relevant information without having to sort through irrelevant information. For example, Noesis, a semantic web search engine developed at the University of Alabama in Huntsville, is designed to filter out search hits that are off-topic.[285] Noesis uses a discipline-specific semantic ontology to match search terms with relevant results, ensuring that a search on tropical cyclones, for example, will not turn up information on sports teams or roller coasters of a similar namesake.

The movement in libraries towards open access has revealed another facet of the semantic web — linked open data. Like linked data, linked open data is organized by resource description frameworks (RDF), contains a unique resource identifier address, and is accessible using hypertext transfer protocol (HTTP), but it only includes openly licensed collections and is the focus of interest in cultural institutions and academic and research libraries around the world. Europeana is a notable example of linked open data; the vision of their foundation and network is to make cultural heritage openly accessible online.[286] The Europeana Data Exchange Agreement is the core element of their licensing framework and requires contributing data providers and aggregators to provide Europeana the right to publish metadata under Creative Commons CC0 1.0 Public Domain Dedication, and each digital object is required to carry a rights label that describes its copyright status.[287] Scholarly information through Europeana can be accessed through searching general terms, specific categories, and phrases; there is also an option to refine searches by filtering by media type, language, country, and more.[288]

Relevance for Academic and Research Libraries

Academic and research libraries are in a unique position to benefit from the increased exposure and contextualization that semantic tools can bring to their collections. Library catalogs will be a more valuable information resource if their metadata is an interoperable part of the semantic web and not siloed in separate inaccessible databases.[289] It is no longer enough for libraries to have their own websites with collection data; there is growing emphasis to integrate these collection catalogs into sites and services more frequently accessed by users. Students and researchers need to be able to connect from Google, for example, back to their specific library.[290] While the evolution of the semantic web is still in its infancy for libraries, the

worldwide linked open data movement is just beginning to adopt international standards for digital repositories that contain bibliographic information.

As an increasing number of librarians recognize the importance of sharing information about collections across institutions, they are forming communities of practice. Linked Open Data in Libraries, Archives, and Museums (LODLAM) is a global network of professionals interested in working with linked open data in their institutions. In their first international LODLAM Summit, more than 100 individuals from 17 countries and 85 organizations convened to collaborate and share resources.[291] The Semantic Web in Bibliotheken Conference in Germany focuses on the semantic web and linked open data in libraries and includes a community of IT staff, developers, librarians, and researchers.[292] The International Federation of Library Associations and Institutions has also created the Semantic Web Special Interest Group where interested professionals can undertake projects that facilitate the adoption of semantic web technologies in libraries.[293] Librarians looking for an introduction to the semantic web can enroll in the Library Juice Academy's asynchronous online course that explores semantic web standards and their applications.[294]

The library community is poised to make great strides with semantic web technologies, as evidenced by projects such as BIBFRAME, which serves as a general model for expressing and connecting bibliographic data. Initiated by the Library of Congress, the BIBFRAME model translates MARC 21 format to linked data and consists of the following core classes: creative work, instance, authority, and annotation.[295] The University of Nevada Las Vegas's OpenRefine is another tool that helps transform metadata into RDF to create linked data.[296] The Online Computer Library Center's recent release of 197 million bibliographic work descriptions through WorldCat Works as linked data is a major step towards providing interconnected access of library data. As a result, library collections can be exposed to a wider community by making collections easily discoverable through websites and services such as Google, Wikipedia, and social networks.[297]

Semantic Web and Linked Data in Practice

The following links provide examples of the semantic web and linked data in use that have direct implications for academic and research libraries:

HathiTrust
go.nmc.org/hathi
HathiTrust is a partnership of academic and research institutions that seeks to help organize and allow access to mass quantities of digital text by making it easily searchable from any device. It currently holds millions of titles digitized from libraries around the world. > *Leadership*

AV Portal at TIB
go.nmc.org/tib
The AV portal of the German National Library of Science and Technology (TIB) provides multimedia retrieval methods for searching within high-grade scientific films from the fields of technology and the natural sciences. Spoken and written language in the video is automatically recorded and can be searched for directly, and Digital Object Identifiers enable scientific films and video segments to be cited as easily as texts. > *Practice*

EDS at Lamar University
go.nmc.org/lamar
Lamar University has used Ebsco Discovery Services (EDS) to create a customized index of the institution's information resources so students can use a single search box but receive more relevant results than they would from Google or outside searches. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about semantic web and linked data:

Impact of Library Discovery Technologies (PDF)
go.nmc.org/impact
(Valérie Spezi et al., UKSG, November 2013.) LISU and the Centre for Information Management at Loughborough University, in association with Evidence Base at Birmingham City University, conducted this research on resource discovery services licensed to libraries. It offers a set of recommendations for each stakeholder group. > *Policy*

Maximizing Academic Library Collections: Measuring Changes in Use Patterns Owing to EBSCO Discovery Service
go.nmc.org/ebsco
(Kristin Calvert, Association of College & Research Libraries, 9 January 2014.) This study measures the impact EBSCO Discovery Service has had on use of library resources through circulation statistics, use of electronic resources, and interlibrary loan requests. > *Leadership*

Discovery Tools: Involving Healthcare Students in Search/Discovery
go.nmc.org/searchdis
(*eLibrary*, 9 April 2013.) Birmingham City University Library and Learning Resources carried out a survey of healthcare students to assess their use of search/discovery tools. This post explains the feedback from that survey of how the healthcare students use different search tools depending on their specific assignments.
> *Practice*

The 2014 NMC Horizon Project Library Expert Panel

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Co-Principal Investigator
New Media Consortium
United States

Lambert Heller
Co-Principal Investigator
TIB Hannover
Germany

Andreas Kirstein
Co-Principal Investigator
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Sue Hutley
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Staffordshire University
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Geoff Payne
La Trobe University Library
Australia

Arlette Piguet
ETH-Bibliothek
Switzerland

Paolo Romano
European Documentation Centre (EDC)
Sistema Bibliotecario di Ateneo Università degli studi "Magna Graecia" di Catanzaro
Italy

Ann Rossiter
SCONUL
UK

Mila Runnwerth
TIB Hannover
Germany

Lindley Shedd
The University of Alabama Libraries
United States

Paul Signorelli
Paul Signorelli & Associates / American Library Association Publishing Committee
United States

Edlef Stabenau
TU Hamburg Harburg Library
Germany

Erik Stattin
Karolinska Institutet University Library
Sweden

Michael Stephens
School of Information
San Jose State University
United States

Aaron Tay
National University of Singapore
Singapore

Pep Tom
Universitat Oberta de Catalunya
Spain

Guus van den Brekel
University Medical Center Groningen, Central Medical Library
The Netherlands

Jakob Voß
Gemeinsamer Bibliotheksverbund
Germany

Endnotes and Links

1 http://go.nmc.org/ios
2 http://go.nmc.org/android
3 http://go.nmc.org/itunes-u
4 http://www.arl.org/focus-areas/e-research/data-access-management-and-sharing/nsf-data-sharing-policy#.U8AVR41dVUM
5 http://www.upenn.edu/president/penn-compact/penn-compact-landing
6 http://researchkb.wordpress.com/2014/01/22/on-line-scholarly-communications-and-the-role-of-digital-archives/
7 http://www.jisc.ac.uk/whatwedo/programmes/di_informationandlibraries.aspx
8 http://blogs.library.duke.edu/blog/2013/07/17/new-app-get-academic-journals-on-your-ipad/
9 http://brown.edu/research/institute-molecular-nanoscale-innovation/
10 http://www.bu.edu/datamanagement/background/whatisdata/
11 http://chronicle.com/blognetwork/theubiquitouslibrarian/2013/08/20/the-3-click-dilemma-are-library-databases-nearing-the-tipping-point-of-obsolescence/
12 http://www.elsevier.com/connect/call-for-papers-international-workshop-on-mining-scientific-publications
13 https://www.ischool.utexas.edu/~palmquis/courses/biblio.html
14 http://aksw.org/Projects/CognitiveEvolutionLD.html
15 http://www.arl.org/focus-areas/e-research/data-access-management-and-sharing/nsf-data-sharing-policy#.U8AVR41dVUM
16 http://research-ethics.net
17 http://www.library.umass.edu/services/services-for-faculty/data-management/data-management-plan-guidance/re-use-and-re-distribution/
18 http://adswww.harvard.edu/
19 http://dcpapers.dublincore.org/pubs/article/view/3683/1906
20 http://www.cs.jhu.edu/balaur/about.html
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Notes

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